STEELWORKER 1 & C

Prepared by

BUREAU OF NAVAL PERSONNEL

NAVY TRAINING COURSES

NAVPERS 10654–A

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1954

First edition, 1950
Reprinted with minor corrections, 1951
Reprinted with changes, 1954

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 70 cents

PREFACE

This book is written for the men of the Navy and of the Naval Reserve who are studying for advancement to the rates of Steelworker First and Chief Steelworker. Combined with the necessary practical experience, the information in this Training Course will help prepare the reader for advancement in rating examinations.

The first chapter of this book contains general information concerning the work and responsibilities of a Steelworker 1 or C. Subsequent chapters deal with rigging heavy equipment, framing of wooden structures, physical and chemical properties of steel, and steel fabrication. Chapter 6 takes up various troubles you may encounter in welding, and short cuts for overcoming welding difficulties. Chapters 7 and 8 contain discussions of the duties of a Steelworker 1 and C as a supervisor and as an instructor.

As one of the NAVY TRAINING COURSES, this book represents the joint endeavor of the U. S. Navy Training Publications Center and the Bureau of Naval Personnel, with technical assistance supplied by the Bureau of Yards and Docks.

STUDY GUIDE

The table below indicates which chapters of this book apply to your rating. To use the table follow these rules:

1. Select the column which applies to your rating. If you are in the regular Navy you will use the column headed SW. If you are in the Naval Reserve you will use the column headed by your particular emergency service rating—SWS or SWR.
2. Observe which chapters have been marked in your RATING column with the number of the RATE to which you are seeking advancement.
3. Study those particular chapters. They include information which will assist you in meeting the qualifications for your rating. See appendix III of this book for the qualifications for advancement in rating. To gain a well-rounded view of the duties of the general service rating, it is recommended that you read the other chapters of this book, even though they do not pertain directly to your rating.
4. Here is an example: If you are a member of the Naval Reserve studying for advancement to the rate of SWS1, you will select the column headed SWS. Following this column down you will observe that you must study chapters 1, 4, 5, 6, 7, and 8.

Chapter	*SW*	*SWS*	*SWR*
1	1, C	1, C	1, C
2	1, C		1, C
3	C	C	C
4	1, C	1, C	
5	1, C	1, C	
6	1, C	1, C	
7	1, C	1, C	1, C
8	1, C	1, C	1, C

READING LIST

NAVY TRAINING COURSES

Steelworker 3 & 2, NavPers 10653-A
Use of Tools, NavPers 10623-A
Blueprint Reading, NavPers 10077
Pipefitter 3 & 2 (chapters 6, 7, 8), NavPers 10592-A
Cargo Handling, NavPers 10124

OTHER PUBLICATIONS

Pontoon Gear Handbook, NavDocks TP-PL-7

USAFI TEXTS

United States Armed Forces Institute (USAFI) courses for additional reading and study are available through your Information and Education Officer.* A partial list of those courses applicable to your rate follows:

Number	Title
CA 769	*Mechanical Drawing* (Correspondence)
MA 769	*Mechanical Drawing* (Self-Teaching)

*"Members of the United States Armed Forces Reserve components, when on active duty, are eligible to enroll for USAFI courses, services, and materials if the orders calling them to active duty specify a period of 120 days or more or if they have been on active duty for a period of 120 days or more, regardless of the time specified in the active duty orders."

CONTENTS

STEELWORKER 1 & C

CHAPTER I

ON THE WAY UP

A STEP UP

On the day you make a rate, the Navy recognizes the skill and knowledge you have gained. That higher rate is not a gift, but something you have earned and to which you are entitled. However, the Navy doesn't give you the rate outright; there are some strings attached to it. You have to take on added responsibility and added duties. These duties and responsibilities are in addition to those of the rate you held previously.

REVIEW

Now is the time for review. You will be examined not only on the qualifications that apply to first and chief but also on those qualifications that apply to 3 and 2. Before you can be a good first or chief you must thoroughly understand the duties of the lower rates.

Give yourself this little test. Turn to the qualifications in appendix III at the back of this book. Go through them and examine yourself on each qualification. Can you read and work from specifications, drawings, and sketches? Has it been a long time since you had an acetylene torch in your hand? Can you still do a good job of welding? Quiz yourself in this manner. If you are 4.0 on each qualification, you are ready to study for first and chief. If you are not 4.0, start to review.

If you have been working at welding most of the time and have forgotten what you knew about rigging, go back to *Steelworker 3 and 2* and reread chapter 3, "Fiber Line and Wire Rope," and also chapter 4, "Rigging." But it isn't enough to just read and understand how to reeve and use common blocks and tackles and how to use jacks, rollers, wire rope, and slings in handling heavy equipment. The items listed under practical factors must actually be performed. So if you haven't done any rigging for a long time, get some actual practice. Go to your chief and request to be placed in a rigging crew for a while. Explain to him that you want to meet the qualifications for advancement. The Navy and your officer in charge are interested in the man who is interested in his job.

After you have completed a review of the practical factors, go on to the qualifications listed under examination subjects. As you go through the examination subjects for 3 and 2, give yourself a mental quiz. Can you still answer questions on the methods and procedures of assembling and launching pontoon strings and structures? It shouldn't take you more than fifteen minutes to go over the examination subjects and list those in which you are weak. When you have recognized your weaknesses, half the battle is won.

ON YOUR WAY

If you now feel that you can get 4.0 on all the practical factors and examination subjects for 3 and 2, you are ready to go on to the qualifications for Steelworker 1 and C. Read them and keep them in mind as you study this and other books pertinent to your job as a Steelworker 1 or chief.

As a higher rated petty officer you will have more responsi-

bility for supervision. You will be placed in charge of rigging, pontoon assembly, and steel erection. When you are in charge of steel erection, you will direct the erection or dismantling of such structures as towers, tanks, hangars, buildings, and bridges. You will be required to lay out and direct the fabrication of structural steel and built-up members in the shop and field in accordance with plans and specifications. Your work in supervising erection and fabrication makes it necessary to draw sketches to show what is to be done. As your work becomes more supervisory in nature, it also becomes more administrative. You will prepare work orders, job requisitions, and job completion and progress reports. Closely linked to these duties is the qualification that calls for you to make material estimates from specifications, working drawings, and sketches. Don't fail to review the quals listed in appendix III, and make sure you are familiar with all requirements applicable to the 1 and C rates.

To advance to warrant officer, you will have to broaden your training and work experience to include the functions of a Builder. When a Steelworker reaches warrant grade he will act as a supervisor on all types of building construction.

STUDY AND TECHNICAL AIDS

While you are studying for advancement in rating there are a number of publications with which you should become familiar since this book can't possibly give you all the answers to all the problems you will have to meet as a Steelworker 1 or chief. Some of these are discussed in the following paragraphs.

Seamanship, NavPers 16118-A and *Knight's Modern Seamanship* will give you valuable help on problems that arise in selecting wire rope, splicing, rigging of loads, and other rigging problems. Manufacturers of wire rope have printed excellent handbooks. These manufacturers' handbooks list breaking strengths of wire rope manufactured according to various specifications, and also give information on splicing and wire rope fittings.

The Navy Training Course, *Builder 3 & 2,* NavPers 10648-B gives you valuable information on all phases of wood construction.

There is one book which will come closer to answering all questions on welding than any other. It is the *Welding Encyclopedia.* You will find this book a valuable one to own and one that you will consult many times.

For the last word on pontoon structures of all types you should consult the *Pontoon Gear Handbook,* NavDocks, TP-PL-2. This manual, written by the Bureau of Yards and Docks, has complete and detailed instructions for assembling of pontoon barges, bridge units, wharves, floating cranes, and floating dry docks.

When you get a job of steel fabrication, you may want to brush up on your blueprint reading and principles of layout. If you do, get *Blueprint Reading,* NavPers 10077. You will also find a valuable section on pipe layout in the *Welding Encyclopedia.*

For information on tank location and erection, *Advanced Base Fuel Storage,* prepared by the Bureau of Yards and Docks will prove to be a valuable guide.

As a Chief Steelworker you may be placed in charge of a platoon and as a first class you may be placed in charge of a squad. The military duties of a squad or platoon leader are the same regardless of his rating. The ability to assume the duties of military leadership are required of every petty officer in the Navy. If you are not up to date on your duties as a platoon or squad leader refer to the *Bluejackets' Manual,* the *General Training Course for Petty Officers,* NavPers 10055, the US Navy *Landing Party Manual,* and the *Guide Book for Marines.* Besides being a skilled craftsman you are required to be a military leader. As you advance, you will be given more military duties and responsibilities.

The battalion education officer will help you get these books when you need them for study and reference purposes.

COOPERATION

If you are given the job of supervising the erection of fuel storage tanks at an advanced base, do not become so absorbed in the task that you overlook the important contributions made by other members of the Navy.

If, after the fuel storage facilities are complete, someone asks you how the tanks got there, what would you say? To reply "We put them up" would, in a way, be right. But, there was really much more to getting the facility erected on that particular island.

How was the location for the base selected in the first place? Who decided how many tanks would be needed? Who bought them? How did they get to the base? Who gave the job to the battalion? The answers to these and similar questions can be summed up in two words—organization and cooperation.

Long before an operation is begun, trained officers on the staff of the area commander determine the location and requirements of the new base. These requirements of men, equipment, and materials are set forth in the BASE DEVELOPMENT PLAN. From the plan, other staff officers order the required equipment and components and schedule the shipping. The officer who is to command the construction troops then assigns the various major jobs to his units. Eventually your battalion is given the job of putting in the tanks at a location possibly selected months before.

When your officer in charge receives the order from his superior, he calls upon the headquarters company to develop the details. The engineering officer develops the specific plans, the supply officer checks to see that all the tools, equipment, and parts are on hand. The job is then given to a project officer, whose responsibility is to carry it through to completion.

Since it takes men to do the actual construction, the project officer first determines how many and what ratings in the construction companies are available to him. He breaks the job down into its parts—staking out the tank sites and pipeline trenches, clearing and grading, actual construction of tanks, installation of pipeline and valves, construction of pump houses, installation and wiring of the pumping machinery. He also plans a time schedule for the operations so the ratings work together as a team.

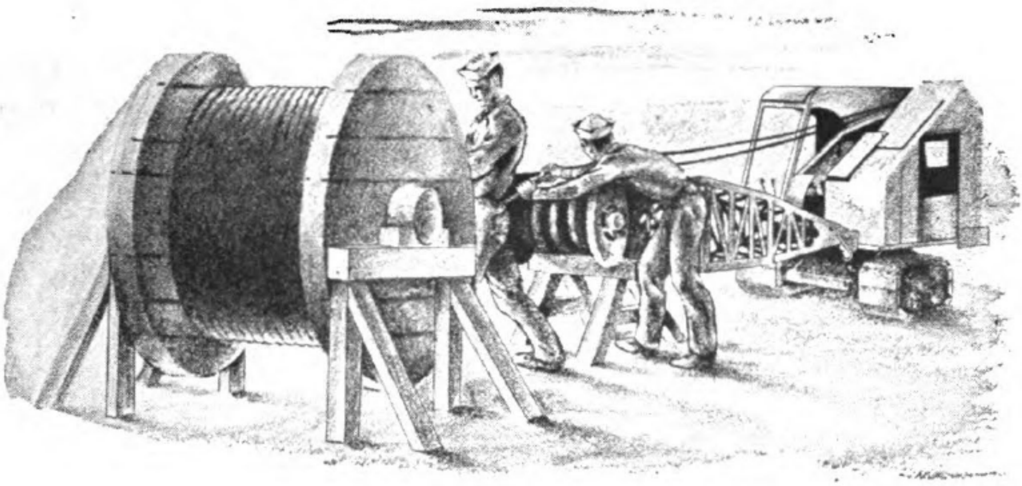
After the plans are completed, you and the other construction ratings come on the job to change the plans from blueprints into a completed facility.

The Surveyors are first on the job. From charts and survey data they set the stakes for the locations of the tank and pump sites and pipeline trenches. Next on the job are the Drivers. They will come in with bulldozers, ditchers and other heavy equipment to clear the sites and dig the trenches. Mechanics come with the Drivers to keep the equipment in good repair. Now the sites are ready for you and your shipmates to begin tank erection. Those tanks won't be much good without pumping equipment, so while you are erecting the tank with the help of the Driver who operates the crane, Builders have been constructing forms and pouring concrete to prepare bases for the pumping machinery.

It isn't the Steelworkers alone who are responsible for the completion of that fuel facility. The combined efforts of the men and officers of the battalion are necessary before the tank farm can refuel the first ship or plane. It takes the knowledge, skill, and cooperation of all the ratings to do the job.

QUIZ

1. To what publication would you refer for an answer to a welding question, if you could not find the answer in a Navy Training Course?
2. What publication would give you the most complete information on pontoon assemblies?
3. If you are studying for Steelworker 1, on what qualifications will you be examined?
4. Who determines the location and requirements of a new base?
5. What rating will usually be the first to go to work on any construction job?



CHAPTER 2

RIGGING HEAVY EQUIPMENT

STEEL TENDONS

Heavy equipment is the muscle of the Seabee battalion. Dozers and scrapers move huge loads of earth. Shovels, clamshells, and draglines bite into mountains for cut and fill. Cranes lift and place steel for tanks and towers, load and unload tons and tons of supplies, and move heavy machinery. Pile drivers drive piles for docks and other water front structures. And all this work is accomplished with tendons of steel. The WIRE ROPE that hoists the shovel's bucket and raises the crane's heavy load is as important in getting the work done as the engine in the piece of equipment.

WIRE ROPE SPECIFICATIONS

When the wire rope parts on a shovel and the Driver on the job rushes to you for help, don't just pick up any piece of new wire rope and expect to get the shovel back on the job. There are a number of things you will have to know before you can pass a wire rope over the first sheave.

First, you should know the make and the model of the shovel. Next, you should know which line has parted. For example, on a Northwest Model 80D, five lines are used to rig the shovel, and wire rope of three different diameters

309247°—54——2

is used to reeve the complete assembly. Unless you have had considerable experience with the reeving of a particular piece of equipment, you should get hold of the manufacturer's manual and look up the wire rope specifications. And, it's a good idea to check the specifications even if you think you know what type of wire rope a particular assembly takes. It's easy to forget that the hoist line of a Model 80D shovel takes a wire center wire rope.

Look at the wire rope specifications in figure 1 and you will see how important it is to select the correct wire rope to reeve a particular assembly.

MODEL 25 WIRE ROPE SPECIFICATIONS

(18′ 0″ BOOM — 15′ 3½″ STICKS)

Hoist rope	¾″ dia. x	94′ 0″ long
Backhaul rope	⅝″ dia. x	27′ 7″ long
Crowd rope	⅝″ dia. x	50′ 0″ long
Boom hoist rope	9/16″ dia. x	115′ 0″ long
Dipper trip rope	5/16″ dia. x	43′ 0″ long

For dipper trip and boom hoist—6 x 19 improved plow steel, regular-lay hemp-center.

For hoist crowd and backhaul—6 x 19 improved plow steel.

Lang lay, with independent wire-rope center, preformed if possible.

Figure 1.—Wire rope specifications for Northwest Model 25 shovel.

For the dipper, trip, and boom-hoist lines, you will use 6 x 19, improved plow steel, regular lay, hemp-center wire rope. But, for the hoist, crowd, and backhaul lines, 6 x 19, improved plow steel, Lang lay, with independent wire-rope center is specified. Rapid wire rope failure would result if hemp-center wire rope were used for the hoist, crowd, and backhaul lines.

If you can't locate the manufacturer's manual for a particular piece of equipment, take off the damaged wire rope and, after you have identified it, replace it with the same kind of wire rope. Of course, you can recognize the lay of the rope, the kind of center it has, and the strand construction, but you will have difficulty recognizing the type of steel used. As a general rule, the wire rope used by the Navy is improved

plow steel, so you can't go wrong in using this type of wire rope to replace any damaged wire rope assembly. Appendix I lists the wire-rope specifications for the equipment most commonly used by the Navy.

REEVING DIAGRAMS

When you are reeving a piece of equipment such as a bulldozer or rooter, you won't need a reeving diagram. However, when you are called upon to reeve a scraper or shovel, you will find that it is much easier to do the job if you have a diagram to follow. As with wire-rope specifications, reeving diagrams will be found in the manufacturer's manuals.

Figure 2 shows the reeving diagram for the dipper-hoist line on a Lorain Model 82 shovel. The reeving instructions accompanying this diagram are as follows:

1. The shovel boom should be in lowered position so cables can be run through the boom head easily.
2. Unroll and stretch out 85 feet of specified wire rope on the ground beside the right-hand side of your machine.
3. Pass the hauling part of your wire rope up and over the right-hand boom point sheave from front to rear.
4. Pass the hauling part of your wire rope under the hoist drum and secure the end in the socket of the drum with a wedge.
5. Engage your machine and wind up the cable on the hoist drum. Leave enough hanging to accomplish the following steps.
6. Pass the standing part of your wire rope down and around the sheave on the dipper block.
7. Then pass the standing part up and over the left-hand boom point sheave.
8. By use of a wedge, secure your wire rope end in the socket at the top of the left-hand boom point.

With the reeving diagram in figure 2 and the foregoing reeving instructions, you should have a good idea of how to

reeve the dipper hoist line on a Lorain 82 before you actually get on the job.

Not all the reeving diagrams, however, will be as clear and explicit as the one shown here, but any reeving diagram will make your job a lot easier.

There will be times when you will be unable to find the manufacturer's manual for a piece of equipment. When this happens, you can make your own reeving diagram. If your job is simply to replace a worn wire rope, you can make a sketch of the assembly to be reeved before you remove the worn line. Don't trust your memory—it takes less time and work to make a sketch than it does to rereeve a hundred feet

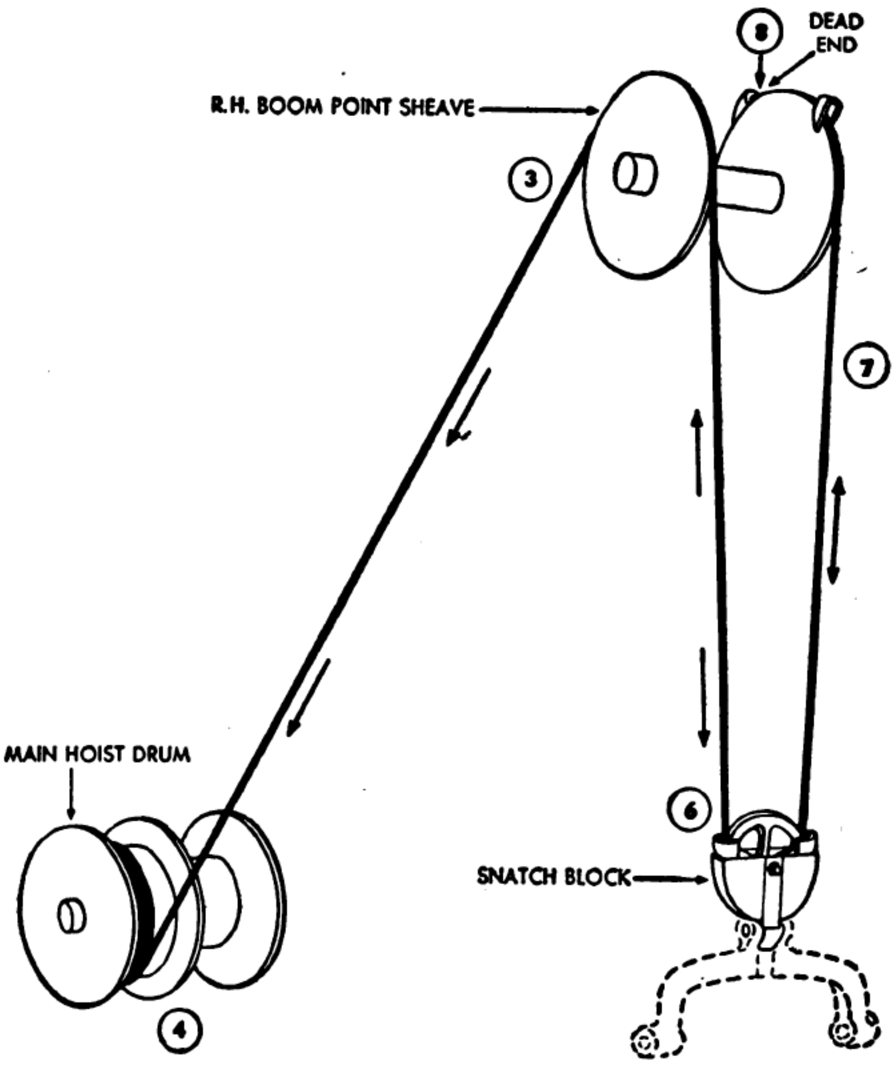


Figure 2.—Reeving diagram for dipper-hoist line, Lorain Model 82.

of wire rope. It's a good idea to make a sketch even if the damaged wire rope is unreeved from the equipment you are to reeve. You can thus plan the work of reeving and you won't have to go ahead in a hit or miss manner. When you draw the sketch, think the rigging problem through. Where will the line be dead ended? Which sheave will it pass over first? Then where will it go? A little planning will save a lot of work.

REEVING A DOZER

A cable-operated dozer will be one of the simplest pieces of equipment you will reeve. Figure 3 shows the reeving diagram for a Laplant-Choate dozer, Model R76B. This type of dozer is commonly used on a Caterpillar D7 tractor.

If you look at the diagram, you will see that the job of reeving a dozer is practically the same as reeving a twofold purchase. Start at the back of the dozer and lead the wire rope over the fairlead above the power control drum, then forward over the left-hand sheave in the top of the front

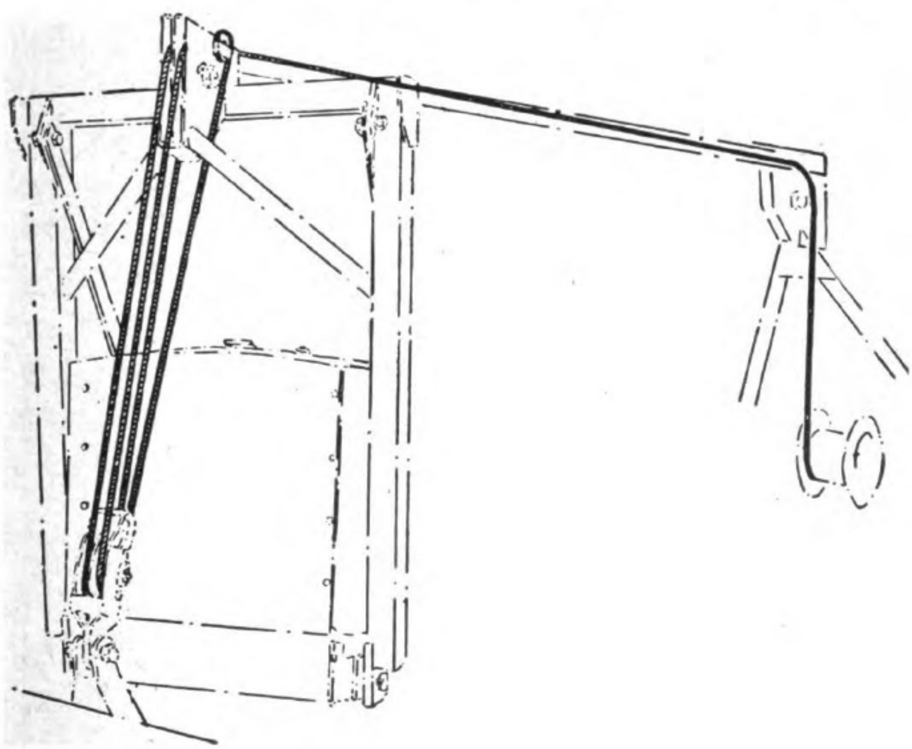


Figure 3.—Reeving diagram for Laplant-Choate dozer.

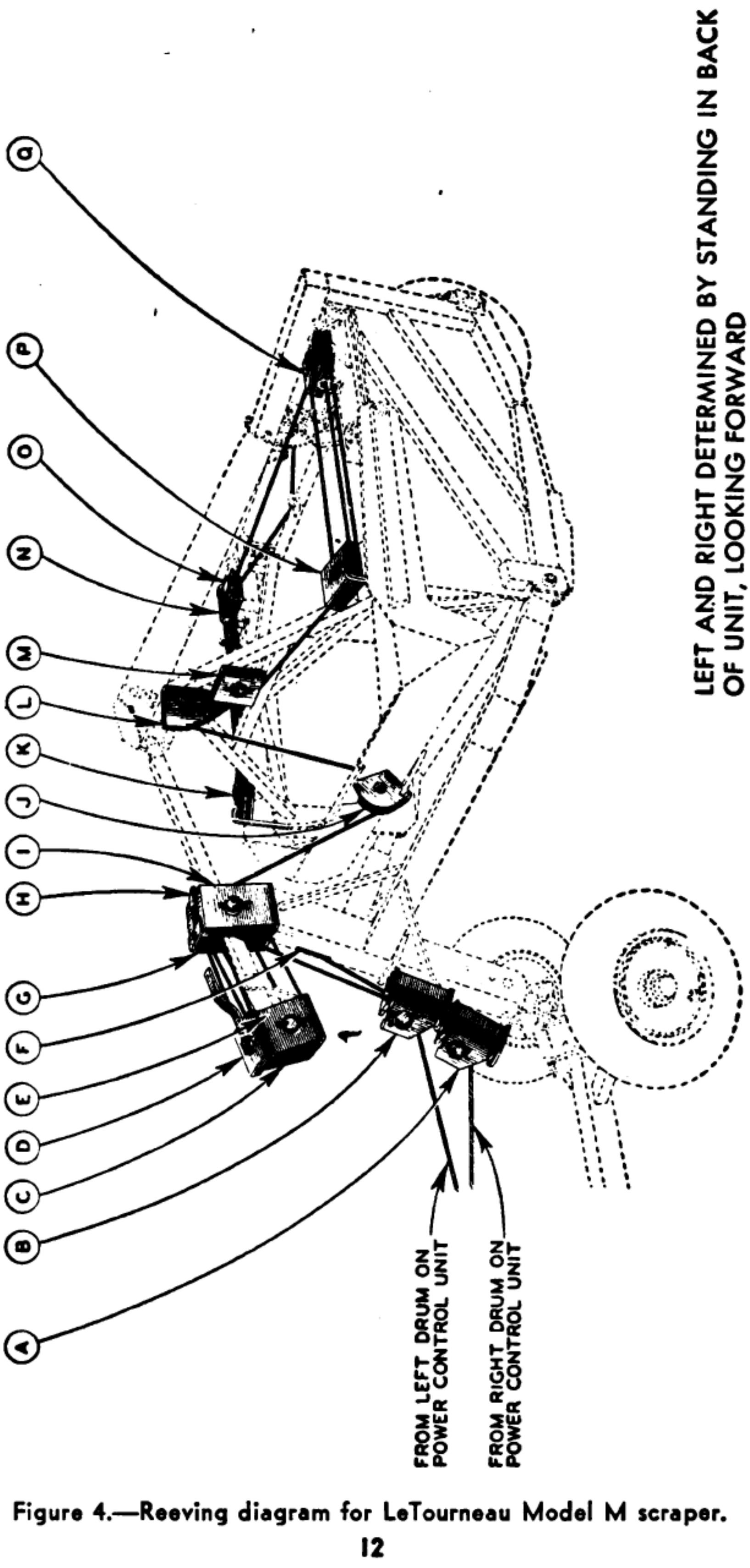


Figure 4.—Reeving diagram for LeTourneau Model M scraper.

dozer frame. Now, lead the wire rope down through the left-hand sheave on the block attached to the dozer blade; up and over the right-hand sheave on the top of the dozer frame; then down through the sheave in the block on the dozer blade. Attach the hauling part to the power control drum with the wedge provided, and secure the standing part to the front frame with the wedge.

There may be slight differences in reeving different makes of dozers. Some may secure the standing part of the wire rope to the blade, but basically all dozers will be reeved in a manner similar to the one illustrated in figure 3.

REEVING A SCRAPER

One of the most difficult reeving jobs you will encounter is that of reeving a scraper. Fortunately, most scrapers carry a spare reel of wire rope which is an integral part of the wire rope that operates the scraper. So it is not necessary to reeve the entire machine when a line breaks. Usually, breaks occur at the fairlead between the scraper and the power control drum. When this occurs, the wedge securing the wire rope is taken out and enough wire rope is unreeled to replace that lost when the line parted.

If you have to completely reeve a scraper, you should start by getting hold of the manufacturer's manual. Unless you have had a great deal of experience reeving scrapers, you will be lost without it.

Figure 4 is the reeving diagram for a LeTourneau Model M, 6-cubic-yard scraper. Observe this diagram as you study the reeving instructions on the following pages. The letter at the end of each step is identified in figure 4.

Hoist Cable

From the right drum on the power control unit, enter and pass the cable as indicated in the following steps:

1. At the bottom of fairlead sheave .... A
2. Up and enter slot in main beam .... F
3. Over the inside sheave in housing .... G

4. Forward and enter top of housing C
5. Back and around outside sheave in housing .... G
6. Forward to top pushbeam sheave .... D
7. Back to outside sheave in housing I
8. Forward and enter bottom of pushbeam sheave housing .... E
9. Through the hole in the top of sheave housing I
10. Dead end at cable wedge .... H

Dump Cable

From cable spool on scraper tailgate, unspool approximately 106 feet of cable, leaving extra cable wrapped on the reel. Then take the end of the cable and extend—

1. From left to right around sheave in housing .... K
2. Back and around top sheave in housing .... N
3. Forward and around bottom sheave in housing .... K
4. Back and enter bottom sheave in housing .... N
5. Across tailgate and around bottom sheave in housing .... Q
6. Forward and around bottom sheave in housing .... P
7. Back and around top sheave in housing .... Q
8. Forward and enter top sheave in housing .... P
9. Across A frame and enter bottom of sheave in housing .... M
10. Up and enter bottom of sheave in housing L
11. Down and enter slot in apron and around sheave in housing. .... J
12. Up and enter inside sheave in housing I
13. Down and enter fairlead sheave in housing ..... B
14. Around sheave in housing B and through the power control unit double-deck sheaves and onto the power control unit left-hand cable drum.

The LeTourneau scraper is one of the makes of scrapers most commonly used by the Navy. You will find that all scrapers made by LeTourneau are reeved similarly to the one described in the preceding paragraphs.

Le Tourneau scrapers have another wire rope assembly

besides the hoist and dump assemblies. This is the spring pipe cable. This assembly rarely breaks, so the method of reeving it will not be covered in this book. Complete instructions for reeving the spring pipe will be found in the manufacturer's manual.

REEVING A SHOVEL

Shovel reeving can be broken down into the reeving of three main lines—the crowd line, the backhaul line, and the hoist line. In this discussion of reeving a shovel, all illustrations and descriptions will refer to the Northwest Model 25. The Navy uses all makes and models of shovels but your chances of reeving a Northwest Model 25 are very good. First, let's take up the reeving of the **Crowd Line.** This is the line that moves the dipper into the face of the excavation. Figure 5 is the reeving diagram for the crowd line. To reeve the crowd line, first measure and cut a 50-foot length of the specified wire rope. Have the dipper stick extended out as far as it will go, as shown in figure 5, before you begin to reeve.

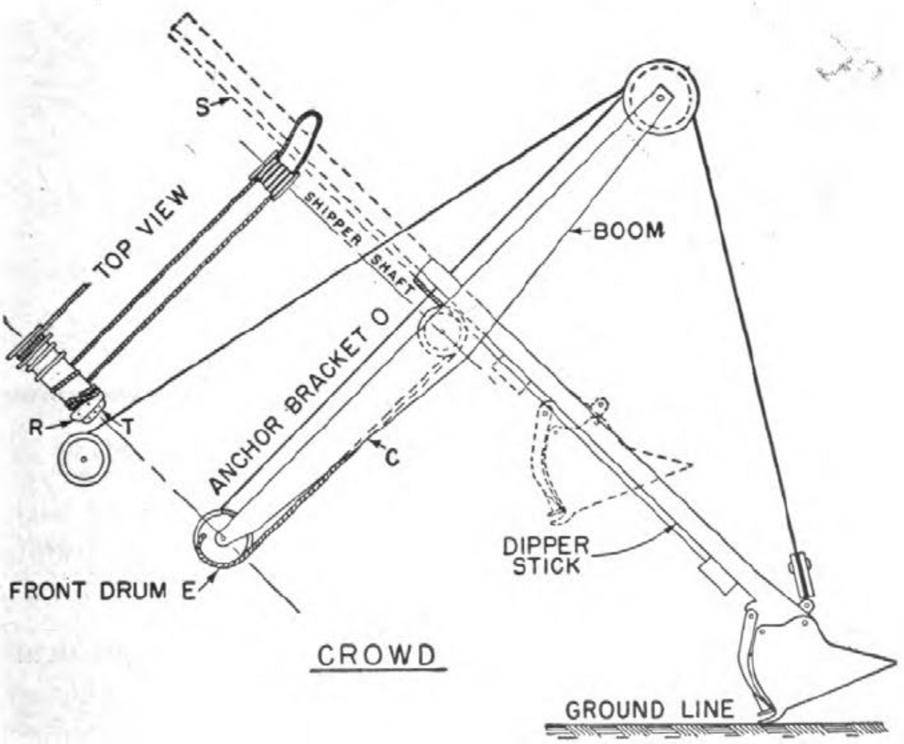


Figure 5.—Reeving diagram for crowd line on Northwest Model 25

Now, reeve the crowd line as follows (consult fig. 5 as you read the instructions):

1. Secure one end of the crowd line C by means of a U-bolt in the socket in the center of the grooved barrel of front drum E.
2. Secure the other end of the crowd line C by means of the wedge in the take-up drum R at the right-hand end of the front drum E.
3. Push the loop thus formed through the opening in the boom and under the two outermost sheaves on the shipper shaft, then up and over the anchor bracket O located at the inner end of the dipper stick.
4. Wind up both ends of the crowd line C by rotating drum E till the line is fairly tight.

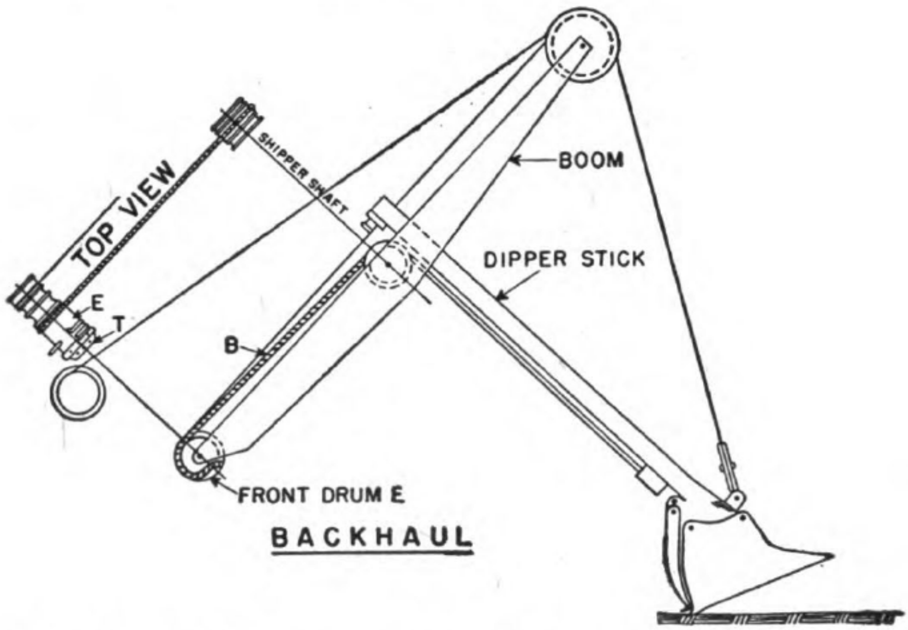


Figure 6.—Reeving diagram for backhaul line for Northwest Model 25.

The BACKHAUL LINE is the line that pulls the dipper stick in. To reeve this line refer to figure 6 and the following instructions:

1. Counting from the upper surface of the front drum E feed the backhaul line B around the drum 1½ wraps and secure it in the wedge socket in the left-hand end of the grooved barrel of the front drum E.

2. Lead the line up over the top of the center sheave on the shipper shaft and then down along the under side of the dipper stick.
3. Anchor the end of the line with the wedge in the adjustable socket at the outer end of the dipper stick. Use this adjustable socket to get the final desired tightness in the line and also to take up slack as the result of wear.

The HOIST LINE is the line that raises and lowers the dipper stick. Figure 7 is the reeving diagram for this assembly.

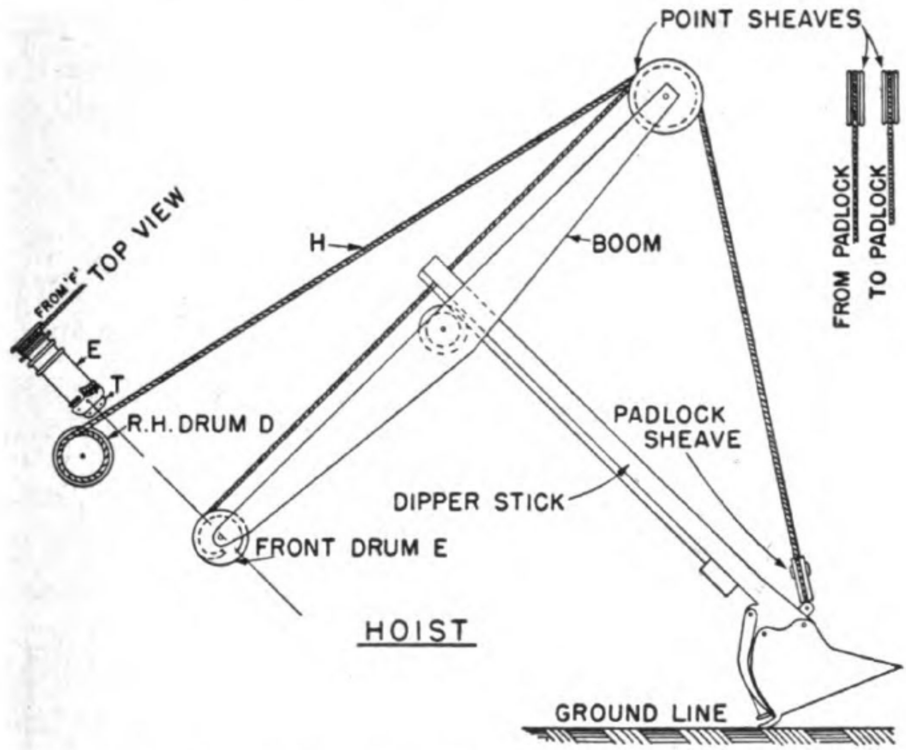


Figure 7.—Reeving diagram for hoist line for Northwest Model 25.

To reeve the hoist:

1. Start at the upper surface of the large diameter portion of the front drum E, wind 1¾ wraps of the hoist line H around the drum and secure the end by means of a wire rope clip in the socket in the flange.
2. Lead the line over the top of the left-hand sheave at the boom point.
3. Pass the line down through the padlock sheave.

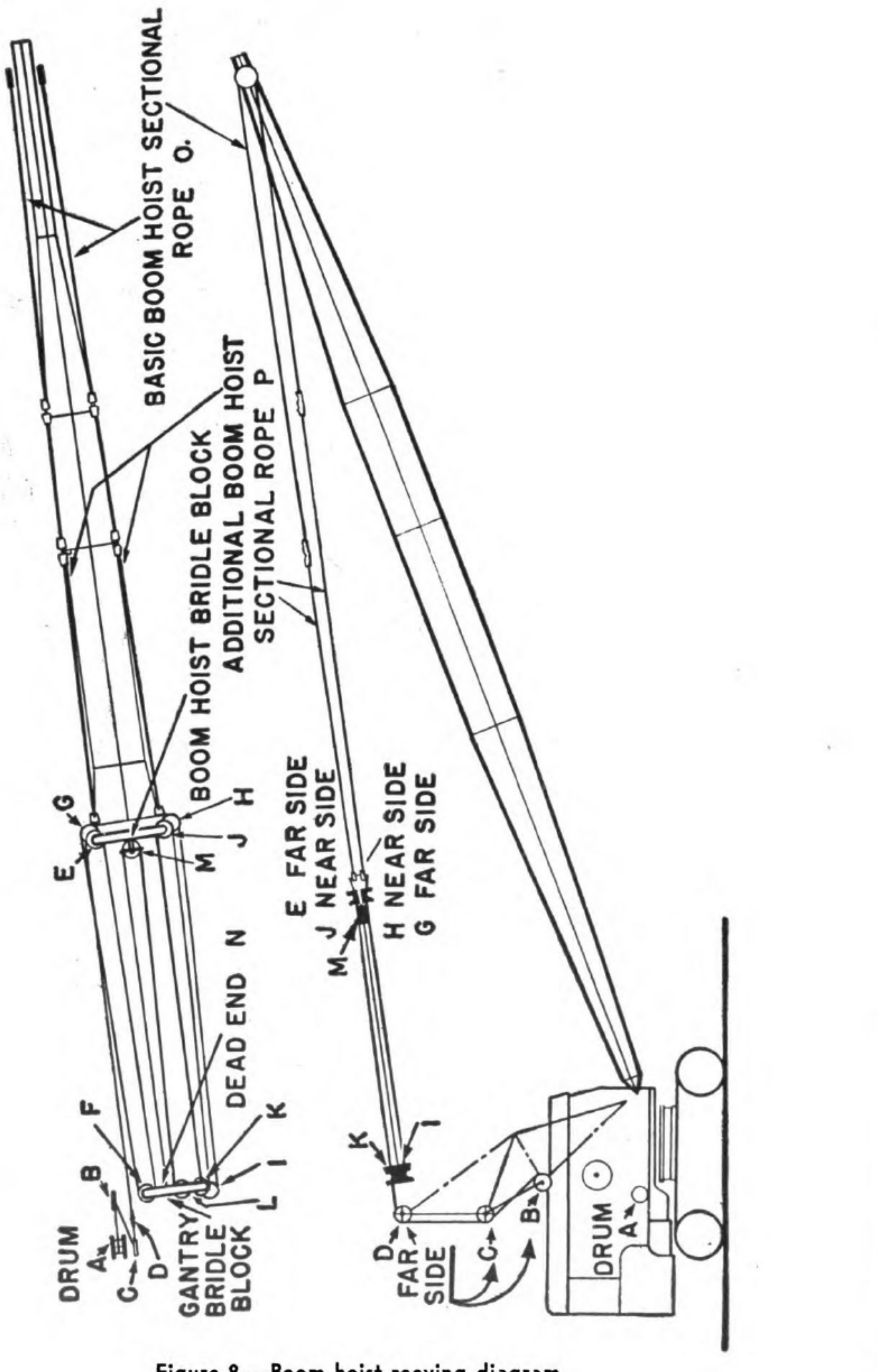


Figure 8.—Boom hoist reeving diagram.

4. Lead the line up and over the right-hand boom point sheave and back to the top of the right-hand drum D on the drum shaft.
5. Secure the end of the line in the socket provided on the drum.

To complete the reeving adjustment of the shovel, wind the rest of the hoist line on to drum D (fig. 7) and move the dipper stick into position S as shown in figure 5. Tighten the crowd line by means of the take-up drum R. Lock the take-up drum tightly by screwing up on sleeve T which is locked to the take-up drum R by means of a capscrew. There are two notches in the outer flange of the take-up drum R, one of which must be in line with any of the capscrew holes in sleeve T before the capscrew can be screwed in place.

REEVING A BOOM HOIST

For this discussion of reeving a boom hoist the illustrations and explanations will be for a Northwest Model 80D.

Figure 8 is the reeving diagram for the boom hoist line. Refer to it as you read the following reeving description:

Lead the line from the underside of the boom hoist drum A to the front side of sheave B on the A-frame, then up to the rear of sheave C, and up to and over sheave D on the gantry. Then lead forward to and around upper sheave E in the boom hoist bridle block. Now, lead the line back to and around sheave F in the gantry bridle block, then forward to and around the lower sheave G in the boom hoist bridle block. The line should now be led across to and around the lower sheave H, then back to and around the lower sheave I in the gantry bridle block. The next step is to lead the line forward to and around upper sheave J in the boom hoist bridle block, and back to and around the upper sheave K in the gantry bridle block. Finally, to finish reeving the assembly, lead the line across to and around sheave L, then forward to and around sheave M and back to dead end at N.

REEVING CRANES AND CLAMSHELLS

A crane is fairly simple to reeve. The crane itself is reeved with one line. The hook block may be reeved as either a whip, a gun tackle, a luff tackle, a twofold purchase, or a threefold purchase depending on the capacity of the crane and the loads to be handled.

Figure 9 is the crane reeving diagram for the Model 82 Lorain.

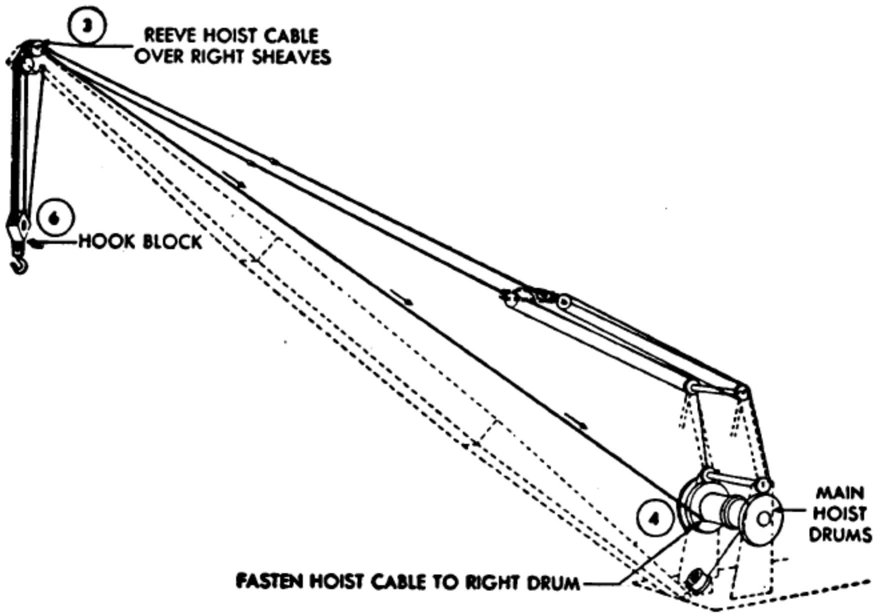


Figure 9.—Crane reeving diagram for a Model 82 Lorain.

The following instructions apply to figure 9:

1. Boom should be in a horizontal position.
2. Remove entire roller cable guard assembly from boom head. Roll and stretch out cable on ground along right-hand side of boom.
3. Pass rear end of cable up and over both right-hand sheaves at boom point from front to rear.
4. Pull rear end of cable down and pass under right-hand hoist drum and secure with cable wedge.
5. Engage machinery and wind up cable on drum.
6. Leave enough hanging from boom head to pass standing part of cable through and around sheaves of hoist block for desired parts of line.

A clamshell is reeved with two lines; the closing line which closes the bucket, and the holding line which holds the bucket when it is dumped. These lines are reeved like a crane line. One line is reeved over the right-hand boom point sheave and one over the left-hand boom point sheave. Before you begin to reeve a clamshell, determine the actual set up for the particular machine you are reeving by consulting the manufacturer's manual.

The clamshell bucket is reeved with the standing part of the closing line, and the holding line is secured to the top of the bucket (see fig. 10). Clamshell buckets may be reeved with either 2, 3, 4, 5, or 6 part line, as shown in figure 10. The sheaves in clamshell buckets have a minimum of clearance, so before you begin to reeve the closing line make sure it is properly pointed. You do this by welding the wires and strands in the end of the wire rope.

REEVING HINTS

There are a number of things about reeving heavy equipment that you will learn through experience on the job. However, here are a few practical hints.

Keep the wire rope clean while you are reeving equipment. Dirt and grit will stick to the lubricant on the cable and cause rapid wear when the machine is in operation. If at all possible, move the equipment to a hard-surfaced area so the wire rope can be stretched out without picking up grit and dirt. If it is impossible to reeve the equipment without getting the wire rope dirty, wipe or brush it off before winding on a drum.

Always have an operator present when you are reeving any piece of equipment. It is often necessary to take up wire rope on a drum before the rest of the assembly can be rigged. The operator of a piece of equipment is the man most familiar with it and best qualified to test the equipment after you have completed your reeving. He may also be of assistance in the actual reeving.

When you are reeving crane blocks do not permanently

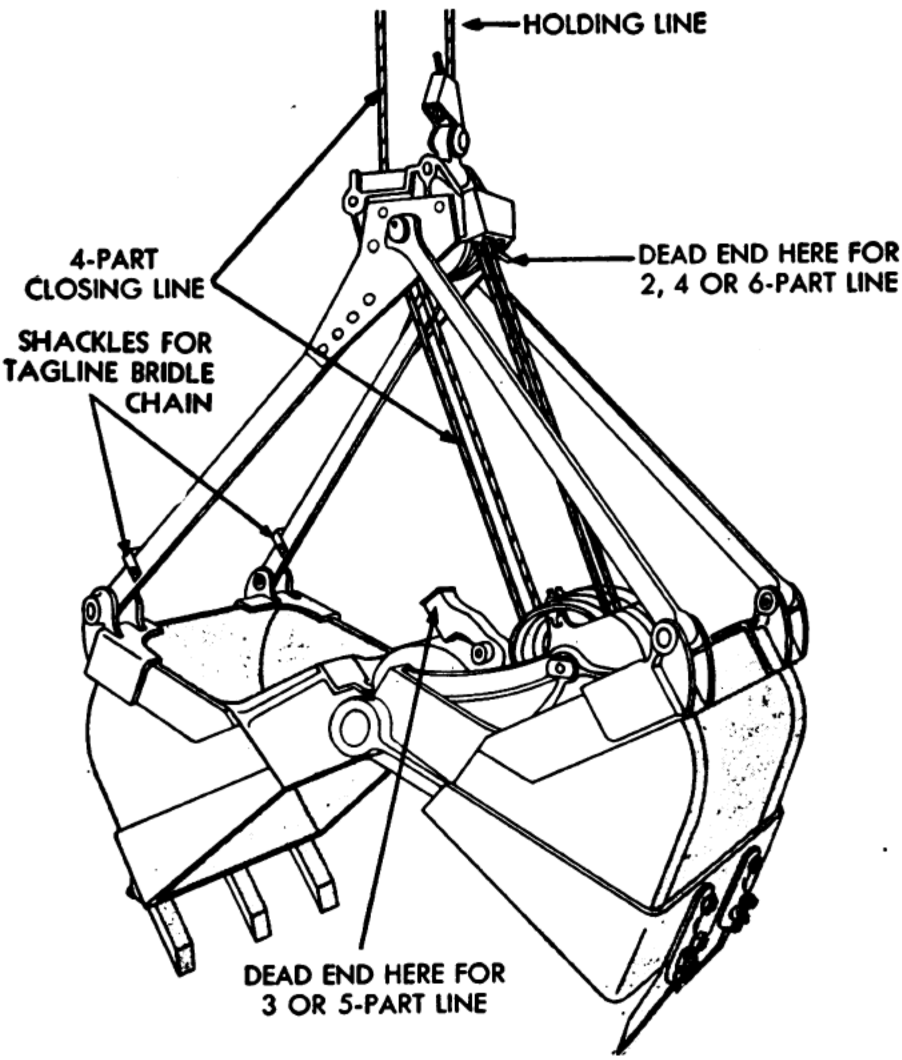


Figure 10.—Clamshell reeving diagram.

secure the standing part of the line until you are sure there will be no twists in the lines. You will have to use a trial and error method to get lines to hang straight by pulling in and taking out twists till the block hangs straight.

You can determine the proper lay of wire rope to use on a particular drum by finding out how the line winds on the drum and to which side of the drum the line is secured. The winding diagrams in figure 11 are self explanatory and apply to either regular or Lang lay rope.

For example, right lay rope should be used on a drum on which the wire rope is overwound from left to right. When the proper lay of rope is used for the drum winding conditions,

the coils will hug together when the load is slacked off and maintain an even layer. With rope of improper lay the coils will spread apart at each removal of load and when winding is resumed, the rope may criss-cross and overlap on the drum causing flattening and crushing.

One way that you can reeve a piece of equipment on which you are replacing a worn line is to secure a piece of six thread to the end of the worn line. As you unreeve the worn line the six thread will follow around the sheaves and be reeved onto the machine. Now, secure the new wire rope to the end of the six thread and pull it back through the sheaves. There is little chance for mistake when this reeving method is used.

When you are reeving a crane, especially when reeving one with a single whip and light hook, it may be necessary to include a "headache ball" in the hook assembly to pull down the line when it is unwound from the drum. A "headache ball," which is a heavy iron weight, may also be used on twofold and threefold purchases to overhaul the blocks.

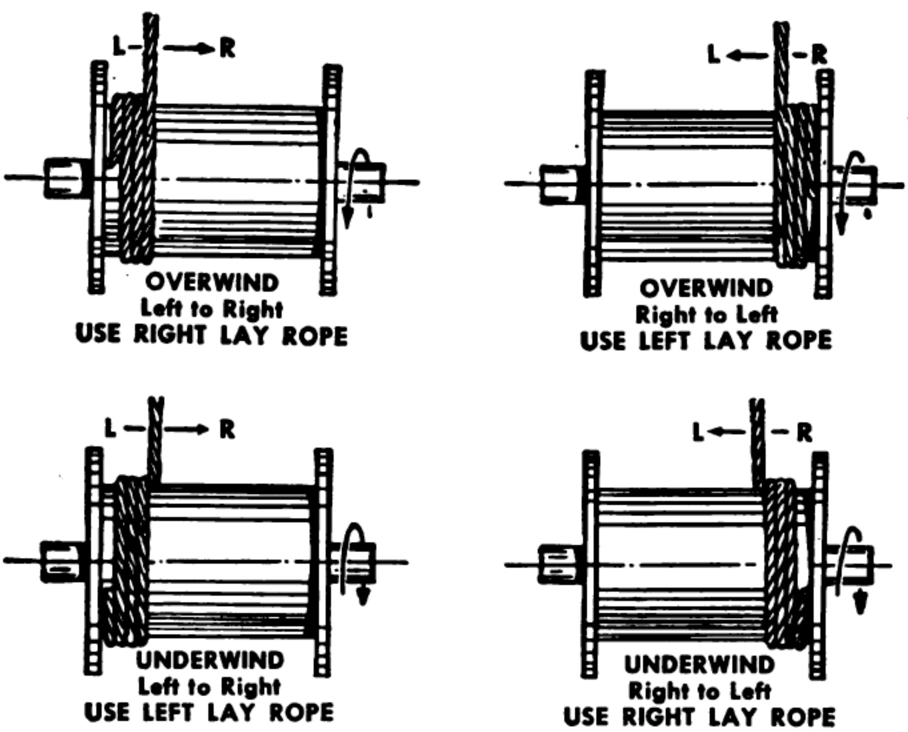


Figure 11.—Drum winding diagrams for selection of proper lay of rope.

WIRE ROPE STORAGE AND STOCK CONTROL

As a Steelworker first or chief, you may be placed in charge of wire rope storage and stock control. If you are given this detail, you should become familiar with class 22 of the *Bureau of Yards and Docks Section* of the *Catalog of Navy Material*. In this publication, under class 22, you will find listed the wire rope carried in stock by navy supply depots, the US Navy Advanced Base Depot at Port Hueneme, and navy supply centers at Guam, M.I., and Pearl Harbor, T.H. You will have to consult class 22 when you order wire rope.

Your job as the man in charge of storage and stock control will be to see that enough wire rope is on hand to meet the needs of the equipment on the base. You will also have to see that the wire rope is safely stored where it can be found when needed and where it will not get wet.

To do a good job on stock control you will have to become thoroughly familiar with the wire rope specifications of the equipment on your base. Your experience in reeving equipment will be of value to you in estimating the life of wire rope on various pieces of equipment under various operating conditions.

You will have to keep a record of the amounts of various wire rope on hand and the amount on order. With these records and your knowledge of the wire rope requirements of your activity, you can reorder supplies in time to keep from running out. Unless you are close enough to a navy supply activity to get delivery in a few days it is a good idea to carry at least a full reel of all commonly used wire rope.

Storage of wire rope should be no great problem. Most reels are weather proof until they are opened. Once they are opened, store them in a dry place under cover.

MATERIAL STORAGE

Part of your rigging work as a Steelworker will be the storage of supplies. The rigging in this type of work will be relatively simple. Most of it will involve the securing of slings and box hooks so that a crane can move the load. The major job is the correct placing and piling of the material.

With the exception of portland cement, most of the material you handle will be stored outside.

Dunnage is essential in any storage operation since it supports and protects the material to be stored. If material were piled up without dunnage the maximum storage capacity of the area could not be utilized, the dampness of the ground might damage the goods, and the job of moving it would be difficult. If at all possible, store goods on a hard-surfaced area, or at least select a site easily cleared of underbrush and well drained. Dunnage may be board lumber, cord wood, or other similar material. Board lumber is the most frequently used, especially for outside storage. Boards to be used as a foundation should be placed between tiers to bind the material, distribute the weight, and furnish a means of ventilation. When you are stacking bagged goods (see fig. 12), the bags should be cross-stacked and a layer of dunnage placed both beneath them and throughout the pile to evenly distribute the weight of the bags. Too much pressure on any one bag will cause it to burst.

If boxed materials are to be stacked, dunnage must be placed beneath the center and both ends of the boxes. Select dunnage

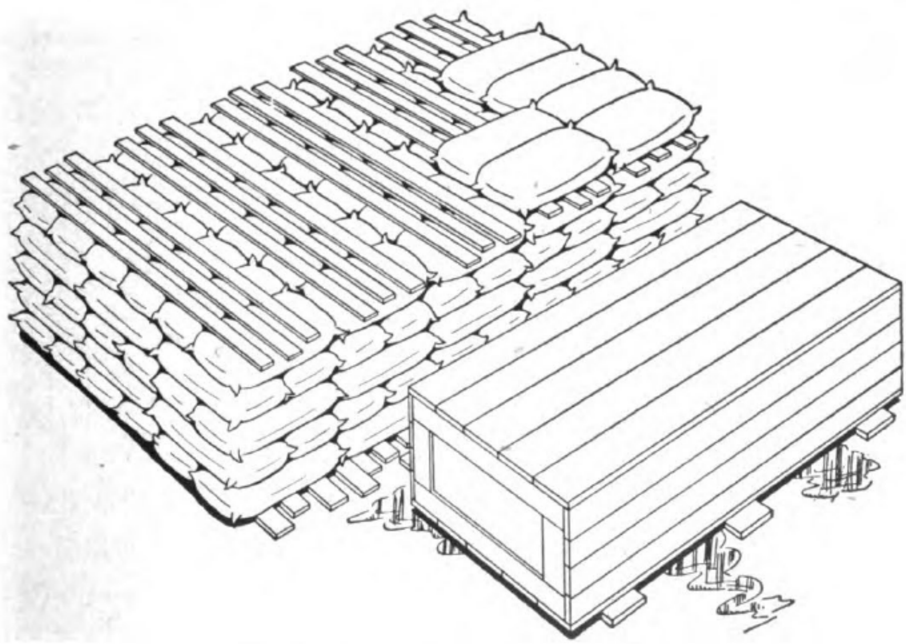


Figure 12.—Methods of using dunnage.

that is flat and reasonably straight so that containers will rest securely and evenly.

Everything the Seabees use—from pontoons to tooth paste —is likely to pass through your storage area at one time or another. Of course, all like material should be placed together. It would be tough to try to find one box of tractor repair parts in a stack of 50 boxes of jeep parts.

One of the most effective means of conserving space is by using the block system of storing. A block is simply a self-supporting, regular pile of supplies, two or more units high, wide, and deep (see fig. 13).

When supplies are stored in blocks the same size containers are placed in each block, thereby eliminating the need for small aisles running through the supplies. Of course, blocks of material should be spaced far enough apart so individual boxes from any one block can be removed.

When you are stacking rectangular boxes, you may be able to tie the stacks together by cross stacking. To cross stack, you place one layer of containers at right angles to the layer below it.

The height of stacks in outdoor storage is limited by the equipment used to handle the material and the material being stacked. Use good judgment in regulating the height of the stacks.

Figure 13.—Block stacking.

The CB's used and still use a lot of lumber. Figure 14 shows the correct method of stacking lumber for outside storage. Timbers should be placed as the dunnage for the bottom of the stack. Place this dunnage in such a manner that there is a slight incline from one end to the other to drain off rain.

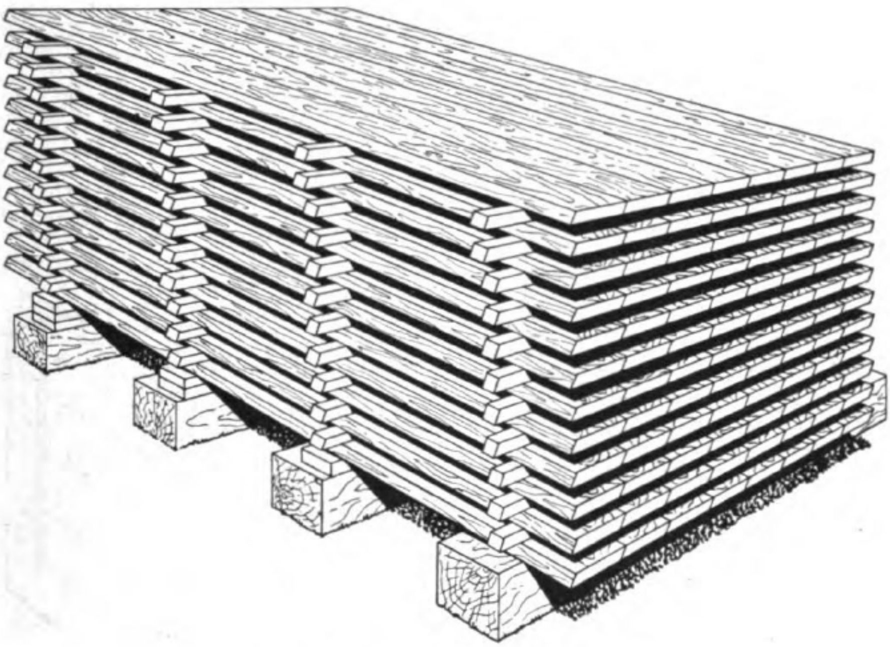


Figure 14.—Stacking lumber.

Pipes should be placed with dunnage between the layers, and chocks should be nailed to the ends of the dunnage to prevent the pipe from rolling.

When rigging loads to be stacked, never use the hoist line of the crane as a sling. Suitable softeners should be placed between slings and metals loads to protect the wire rope and prevent it from slipping out (see fig. 15).

RIGGING SAFETY

As a first or chief, you will, in all probability, be in charge of a rigging crew. The most important duty you will have as a supervisor is to run a safe job. There is no place for mistakes in rigging. A mistake on the part of a rigger can easily cause loss of life and the destruction of valuable property.

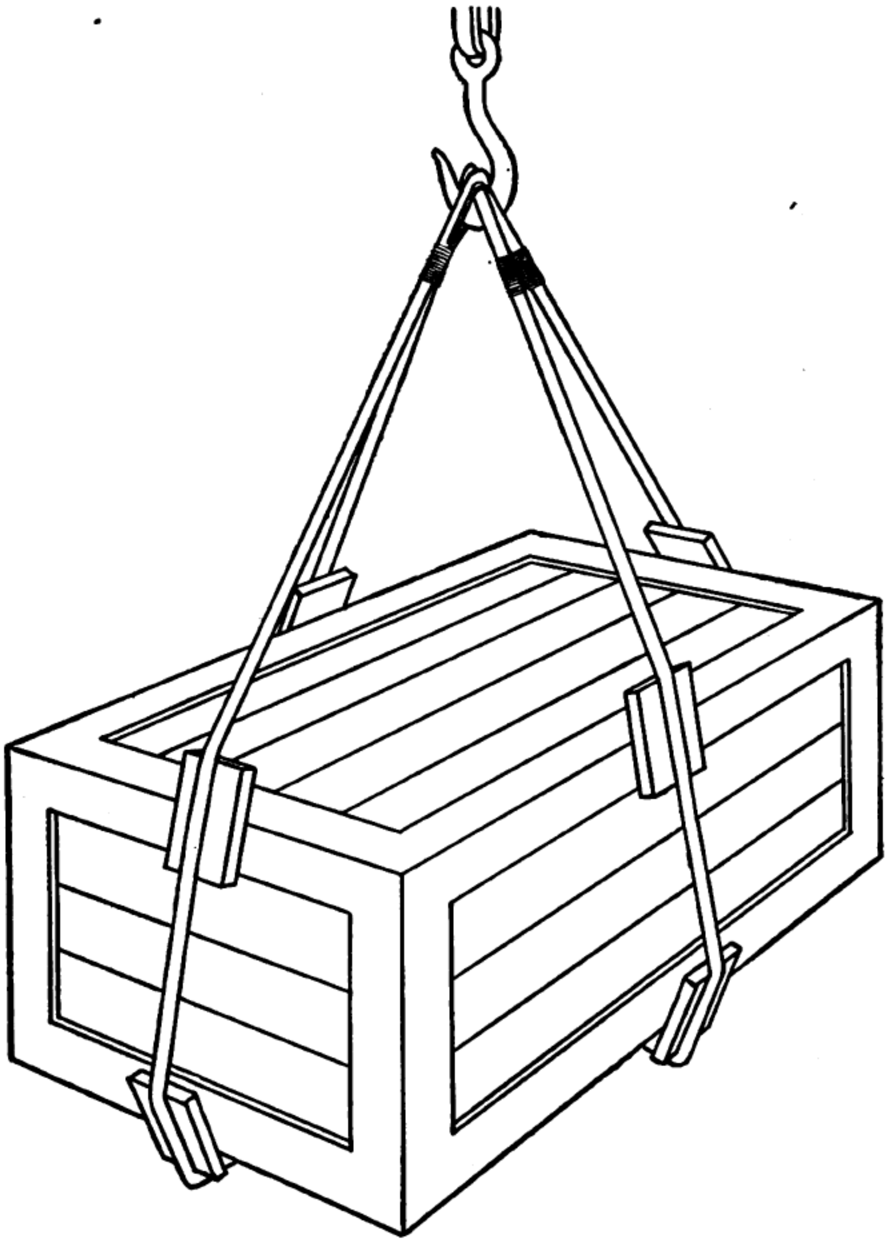


Figure 15.—Softeners on a load.

Be sure the following safety rules are understood by all the men in your crew and see that they are rigidly enforced.

1. Only one man may give signals (he must use standard hand signals) and all men in the crew should be so instructed. The only exception to this rule is that an emergency stop signal given by anyone must be obeyed.

2. Riding on the hook or load is prohibited. There are no exceptions to this rule.
3. In all hoisting operations, the hooking-up must be completed before the signal to hoist is given.
4. Only experienced men may make slings or hook on loads. Great care should be taken to see that the load is properly secured.
5. Signalmen, hook tenders, etc., must warn all men and see that they keep out from under loads and booms.
6. In handling all heavy material where rigging is necessary, the supervisor must specify and examine rope blocks, slings, chains, and other necessary material for size and condition.
7. More accidents occur because of carelessness in handling small material than when handling larger material. When handling small material, take extra precautions. Remove all small pieces that may be lying on material that is to be lifted.
8. Always place softeners on all sharp corners with which ropes, slings and chains might otherwise come in contact, especially in cases where the sling might slide.
9. Do not lift a piece of assembled apparatus or equipment without first making sure that the assembled parts are securely bolted.
10. Do not carry a load on the point of a hook.
11. Avoid sharp bends or kinks in slings. When a heavy load is to be lifted, it must be raised a few inches and allowed to hang a minute or two, so balance can be checked and brake capacity tested.
12. The hoist cable must not be wrapped around a load. The load should be attached to the bottom hook by means of slings or other approved devices.
13. All rigging gear, when not in use, should be kept on the crane and inspected for defects by the supervisor before being used again.
14. Always place dunnage or softeners before load is moved into place. Never place hands or feet under the load to adjust dunnage—use a board or crowbar.

15. Do not stand between the load and a stationary object at any time.
16. Tag lines must always be available on the crane and used whenever necessary to control the swing of the load, especially in the handling of long material such as piling or pipe.
17. All men must be in the clear when slings or hooks are pulled from under the load by the crane.
18. Riggers, as well as crane crewmen, must be aware of the great danger of becoming caught between stationary objects and the rear end of cranes.
19. Before the operator moves a crane upon which an empty sling is hanging, the sling supervisor should hook both ends of the sling to the hook.
20. Sling hookers should never attempt to hold the sling taut with the hands while the crane takes up the slack.
21. All riggers must wear a safety helmet, leather gloves, and hard-toed safety shoes to guard against head, hand, and foot injuries.

TRICKS OF THE TRADE

If you have ever been on a difficult rigging job with an experienced rigger you have had a splendid opportunity to learn a lot. There are numerous books on rigging that will give you a great deal of information, but the tricks of the trade that the old hand at rigging has acquired is the rigging "know how" that will get the job done most efficiently. You have already learned many of these short cuts; here are a few more.

If you have the problem of lowering a heavy load into a confined space where it is impractical to use jacks, you may be able to support and lower the load by using ice. If the load is supported on cribbing, jack it up and as you remove the cribbing replace it with blocks of ice. After you get the load supported by the ice, it can be lowered as desired by melting the ice with blow torches or other sources of heat.

Large petroleum storage tanks that would be most difficult to move by conventional methods can at times be moved by employing water. Approximately 4 feet of water will float a 10,000-gallon tank. So, if equipment is available to construct

a dike, and water and pumping equipment are available to keep the dike filled, the tank may be floated to a new location.

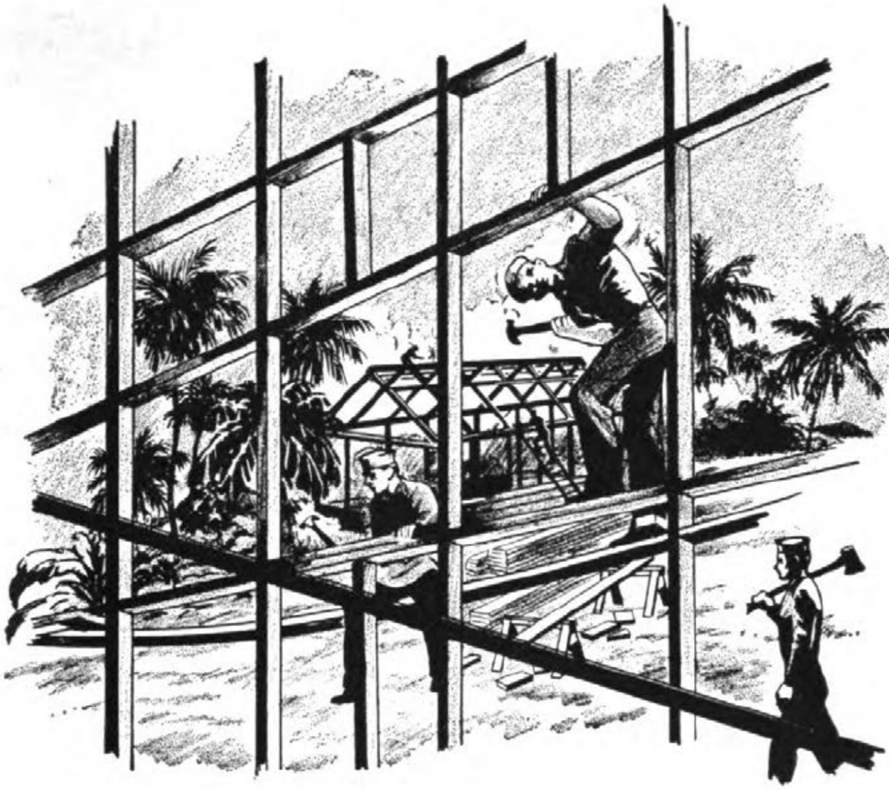
There will be times when it is necessary to rig a piece of machinery so that it can be lowered over studs in a foundation and alined very accurately. In doing precise work of this nature, you will find that one or two chain falls rigged from the crane hook to the slings supporting the load will enable you to lower and raise the load the small amount necessary to accurately place it in position.

There is usually more than one way to do most rigging jobs. The method you use will depend on the equipment available and your own judgment. You should be on the alert for better methods of doing the job and for learning new tricks of the trade.

QUIZ

1. Before you can start to reeve a piece of heavy equipment what must you know?
2. Where will you find the wire-rope specifications for heavy equipment?
3. Besides the wire-rope specifications what other information will aid you in reeving a piece of equipment? Where can you get this information?
4. When you can't find a reeving diagram what should you do before beginning the reeving job?
5. Reeving a dozer is similar to what other reeving job you have performed?
6. What lines will you most likely reeve on a shovel?
7. What is the function of the hoist line on a shovel?
8. What position should the boom be in when you are reeving a model 82 Lorain crane?
9. If you are reeving a crane block, when should you permanently secure the standing part of the line?

10. What class is wire rope listed under in the *Bureau of Yards and Docks Section* of the *Catalog of Navy Material?*
11. What is the function of dunnage?
12. What is your most important duty as a supervisor in charge of a rigging job?



CHAPTER 3
BUILDING WITH WOOD

WHY

The rate you hold means that you are a specialist in building with steel; so, you may ask yourself, "Why is there a chapter on building with wood in a Steelworker's Training Course?" Since you and the Builder will both advance to the same warrant grade and because your rating is most closely related to the rating of Builder, it is important that you acquire some knowledge of carpentry. As a Steelworker first or chief there may be times when you are in charge of a job that involves both steel work and carpentry. To adequately perform your duties as the leading chief or first class under such conditions you will have to know at least the fundamentals of framing.

TERMINOLOGY

To understand the fundamentals of framing you should begin

by learning the various terms that designate the parts of a frame. First the term FRAME should be understood. The frame of a building corresponds roughly to the skeleton in the human body. It is made up of the structural members that support the outside and inside walls, the roof, the partitions that divide the building into rooms, and the members that support the floors. Each of these members has a name depending on its function. Identical pieces of lumber will be designated by different names according to their place in the frame.

Let's begin at the bottom of a building and examine the frame members as they would be placed in a wooden building.

The first frame member to be put in place after the foundation is complete is the SILL—or, as it is sometimes called, the FOUNDATION SILL. The sill forms the support or bearing surface for the outside of the building. It provides a smooth level surface on which to place other framing members (see fig. 16).

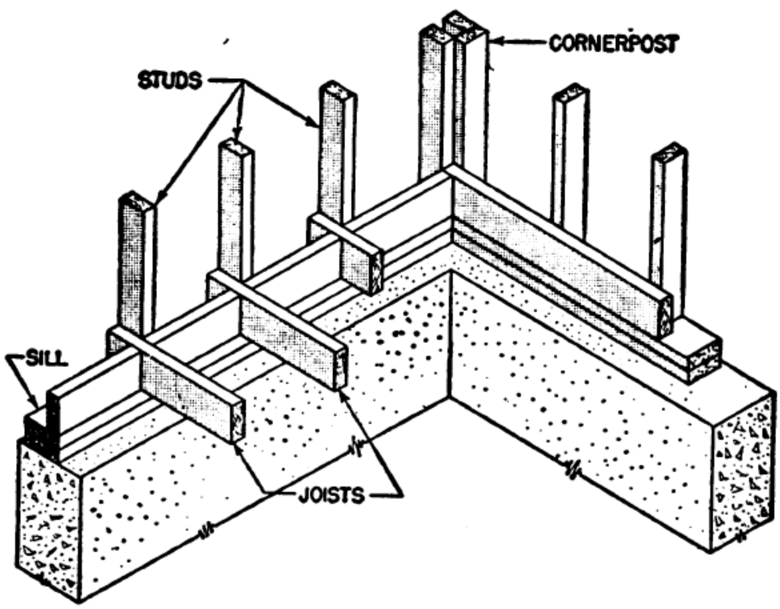


Figure 16.—Sill, joists, corner post, and studs.

JOISTS are illustrated in figure 17. As you can see, joists are the framing members that support the floor and ceiling. In a two story building the ceiling joists would also support the second floor.

A GIRDER (fig. 17) is a timber or iron beam, either single or

built up, used to support joists or walls over an opening. Generally, girders are used to support joists when the unsupported span of the joists would be excessive.

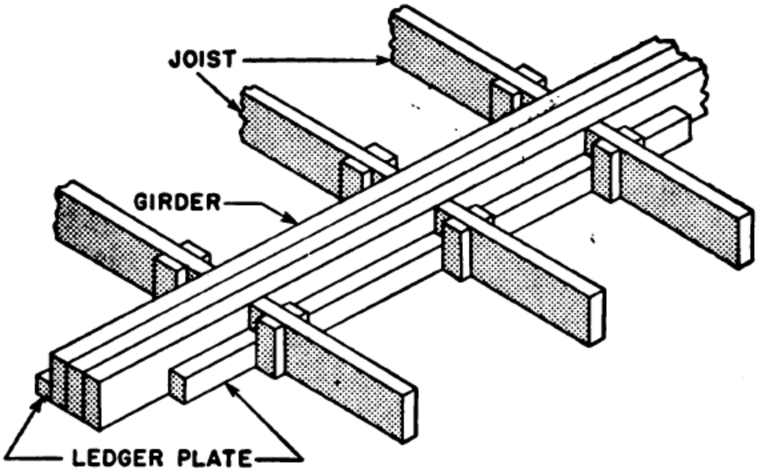


Figure 17.—Girder.

STUDS OR STUDDING are the vertical members of the building to which outside walls are nailed. Studs is also the term used to designate the vertical supporting members of partitions (see fig. 16).

CORNER POSTS OR CORNER STUDS are those studs at the corner of the building. They are heavier than the other studs and may be either built up or solid timbers (see fig. 16).

A BRACE is an inclined piece of lumber used to stiffen the framing. Braces may be temporary to hold a part of the framing in place so it can be trued up and nailed or they may be a permanent part of the building. Figure 18 shows both types.

BRIDGING is a special form of bracing. It is used to stiffen floor joists and partition studs. Cross bridging, the most commonly used form of bridging, is shown in figure 19.

A RIBBON is a horizontal frame member usually found at the second story level of a building. As a general rule it is set into the studs. The ends of the second story floor joists rest on it. Ribbons are sometimes referred to as ledgers. (See fig. 20).

As you can see from figure 20, the PLATE corresponds roughly to the sill. It is supported by the studs and, in turn, supports the rafters. The RAFTERS are the members of the

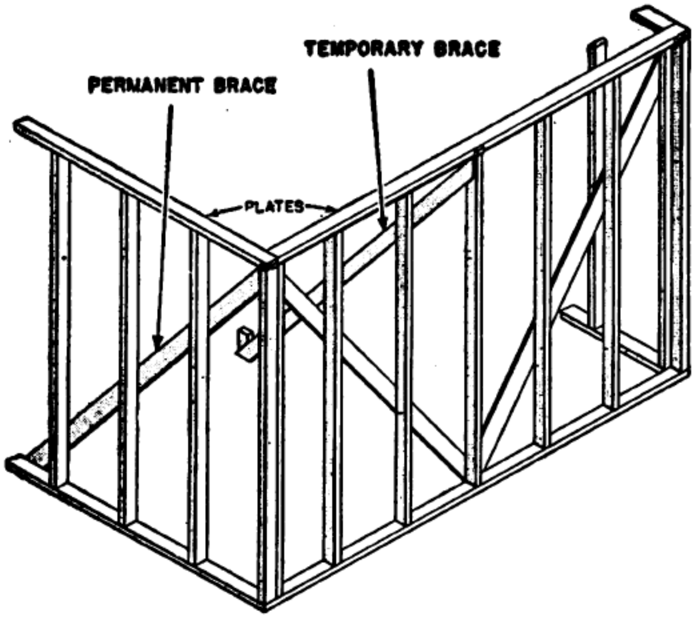


Figure 18.—Braces.

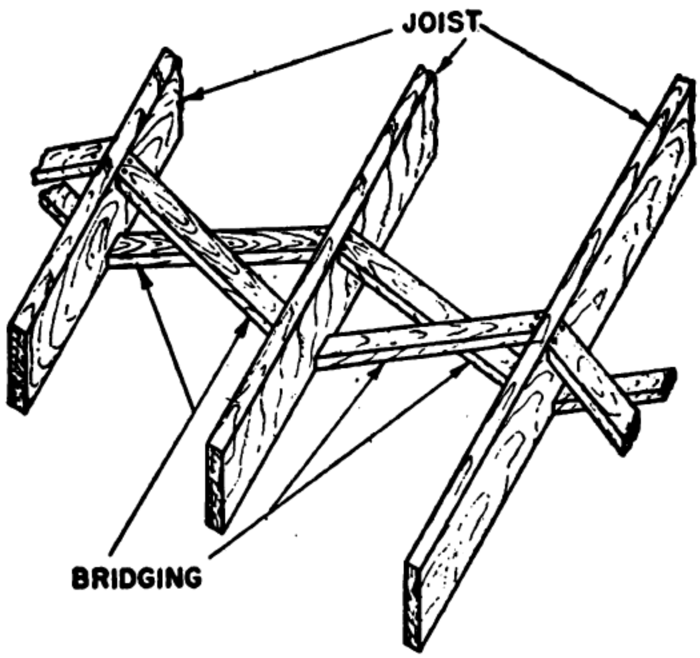


Figure 19.—Cross bridging.

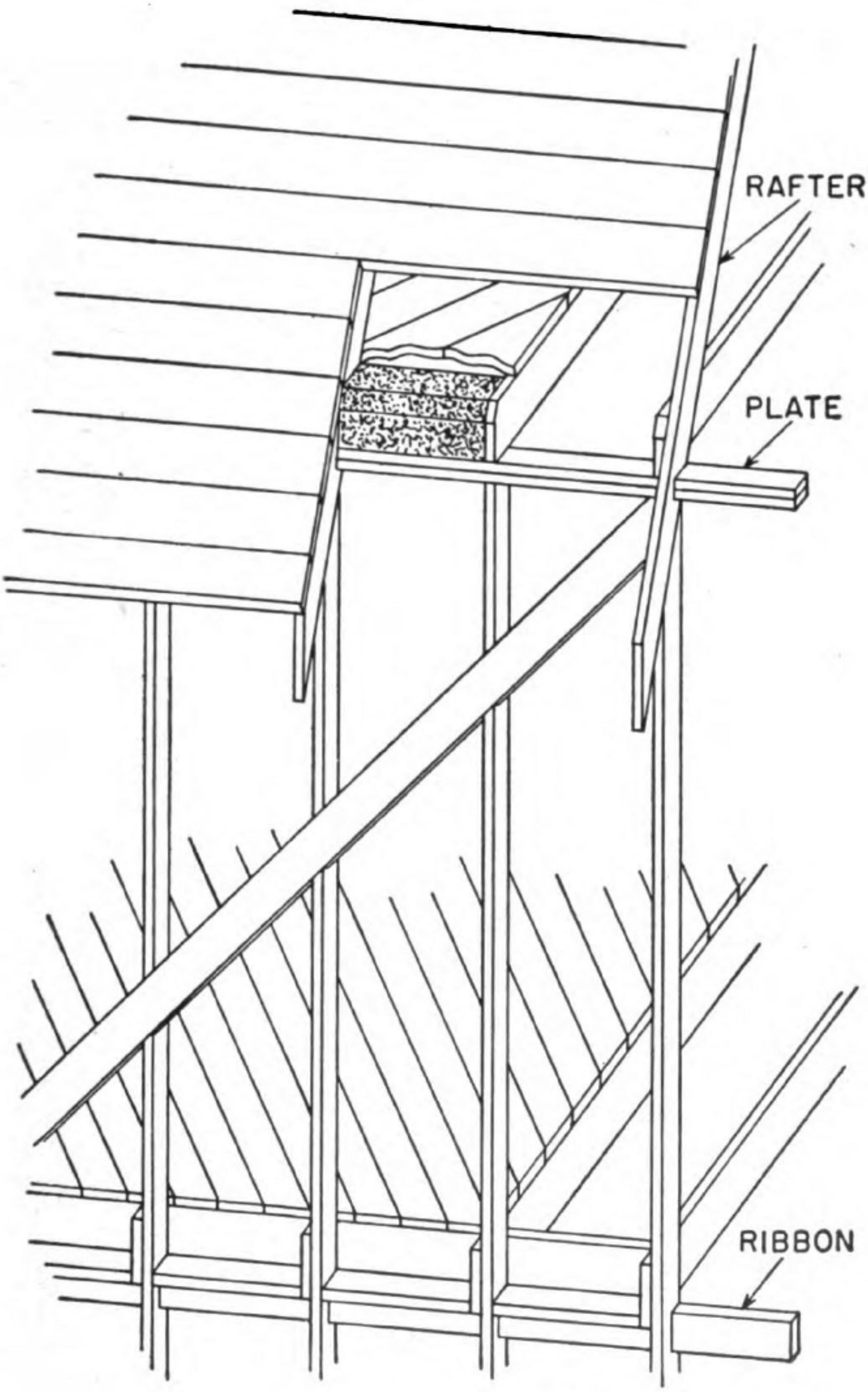


Figure 20.—Ribbon, plate, and simple rafters.

frame that support the roof. There are various kinds of rafters as shown in figure 21.

COMMON RAFTERS join at the ridge to make an angle. The RIDGE is the structural member at the top of the roof. The rafters are supported at their bottom ends by the plate, and at the top by the ridge.

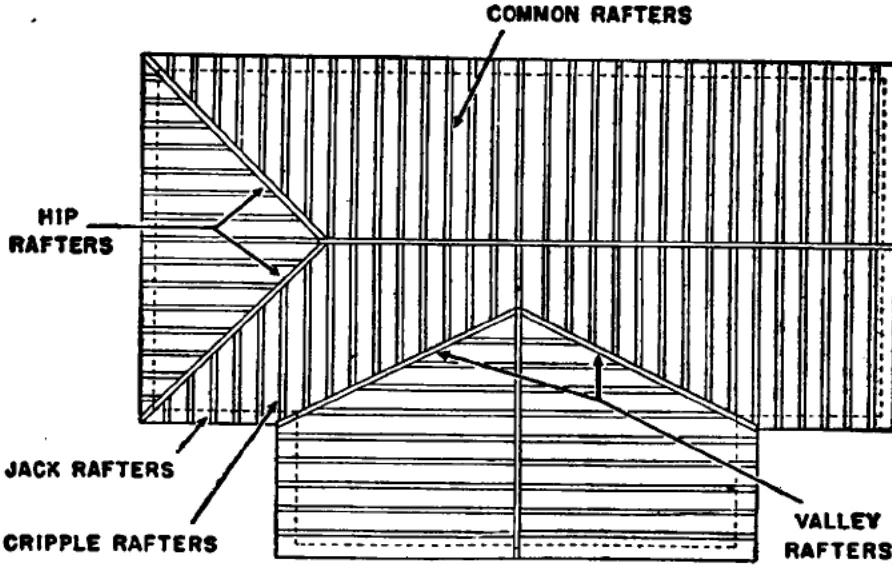


Figure 21.—Various kinds of rafters.

HIP RAFTERS extend diagonally from an outside corner of the plate to the ridge.

VALLEY RAFTERS extend diagonally from the plate to the ridge at an inside corner or at the intersection of the gable extension with the main roof (see fig. 21).

JACK RAFTERS are short rafters, extending from the plate to another rafter or the ridge (fig. 21). Those rafters extending from the plate to a hip rafter are termed HIP JACKS. Those extending from a valley rafter to the ridge are called VALLEY JACK rafters. CRIPPLE RAFTERS are not supported by either the plate or the ridge but extend between a hip rafter and a valley rafter.

Figure 22 shows header and trimmer construction. A HEADER is a short transverse member that supports wall studs or floor framing at the point where they are cut off to form

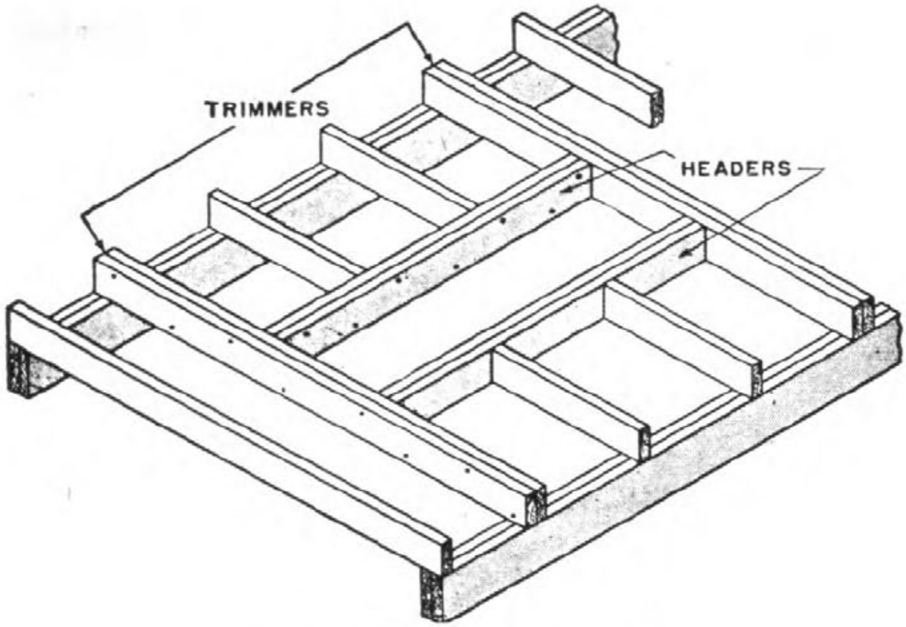


Figure 22.—Header and trimmer.

wall or floor openings. A TRIMMER is a carrying joist or stud which supports an end of a header.

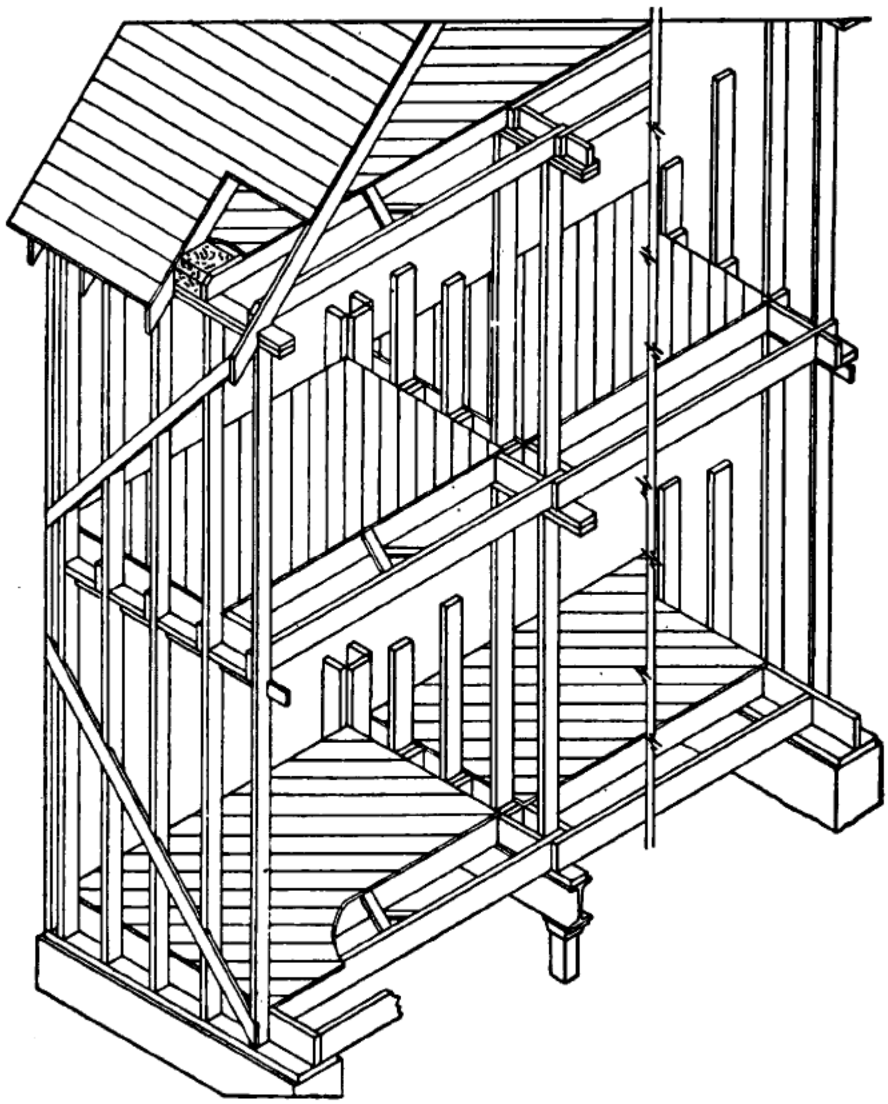
BUILDING FRAMES

Since you will be in charge of jobs that for the most part involve only light-wood framing (a builder will be in charge of heavy construction), only the two most common types of light-wood framing will be discussed here.

Light-wood framing is used in residence and smaller types of buildings where the loads are light. The two types of light-wood framing most commonly used are the balloon frame and platform frame. There are modifications and variations in detail to these two general methods, but fundamentals readily come under these two types of framing.

There are two other types of framing you may hear mentioned. They are full framing and combination framing. These ordinarily will not be used in Navy construction.

BALLOON FRAMING (see fig. 23) is cheap, light, and quickly constructed. It has several disadvantages in that it is not as rigid or permanent and is more readily consumed by fire than other types of framing.

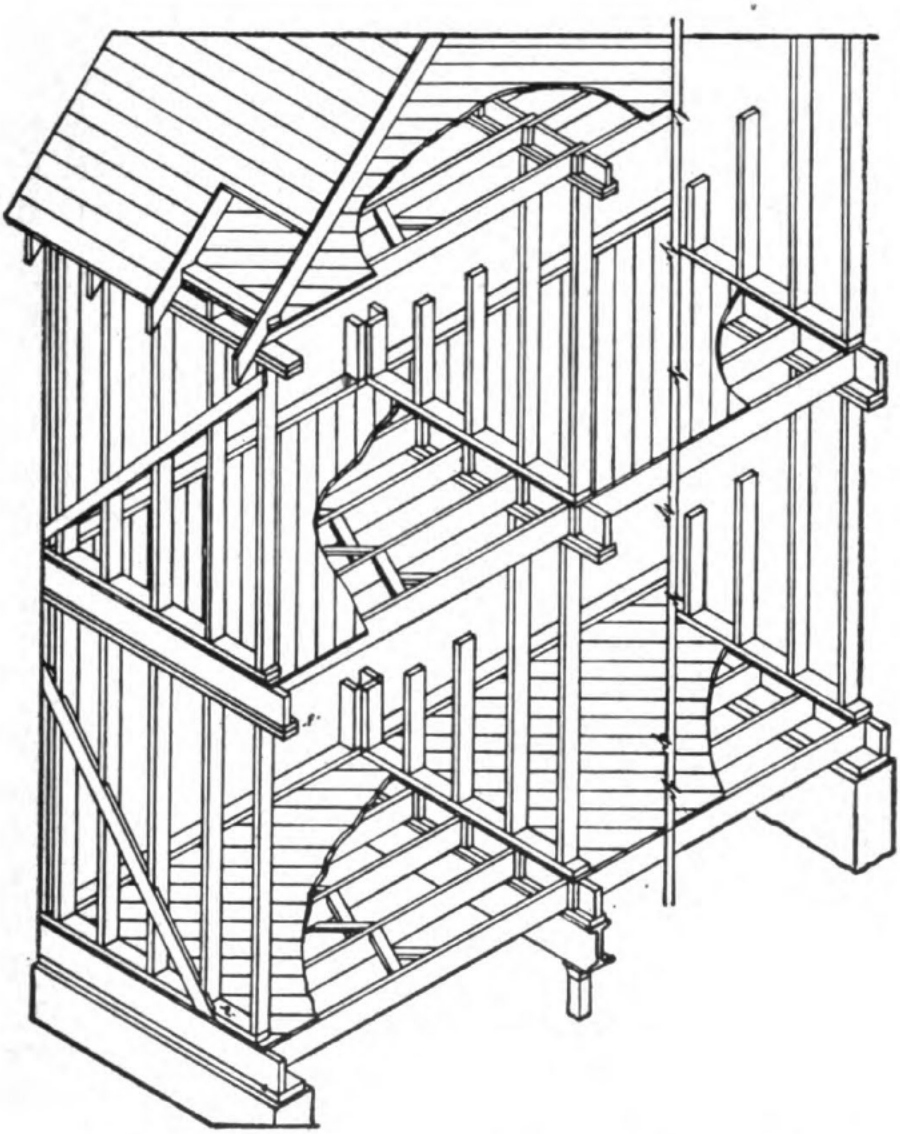


—*Courtesy of Delmar Publishers.*

Figure 23.—Balloon frame.

In balloon framing the sills are laid on the foundation and secured with anchor bolts. The first-story joists are spiked in place on the sill, and the corner posts are set in position and held by temporary braces. In one method of construction the studs which run from the sill to the plate, are spiked into position on the sill and held near their upper ends by temporary boards nailed across them. The ribbon is nailed into the notched studs and lower posts at the proper height to support the second-story joists, which are nailed in place next. A joist is brought against a stud whenever possible. The plate is

nailed on top of the studs and halved together over the corner posts. The outside boarding should be nailed on diagonally to brace the frame. The long slender studs; the light sill, plate, and corner posts; and the omission of bracing tend to make this a frame lacking in rigidity. It is, therefore, likely to sway, creak, and tremble in heavy winds. Unless the building is insulated or constructed with fire stops at the floor levels, the long unencumbered spaces from the sill to the roof-eaves provide excellent flues for the passage of flames and make the



—Courtesy of Delmar Publishers.

Figure 24.—Platform frame.

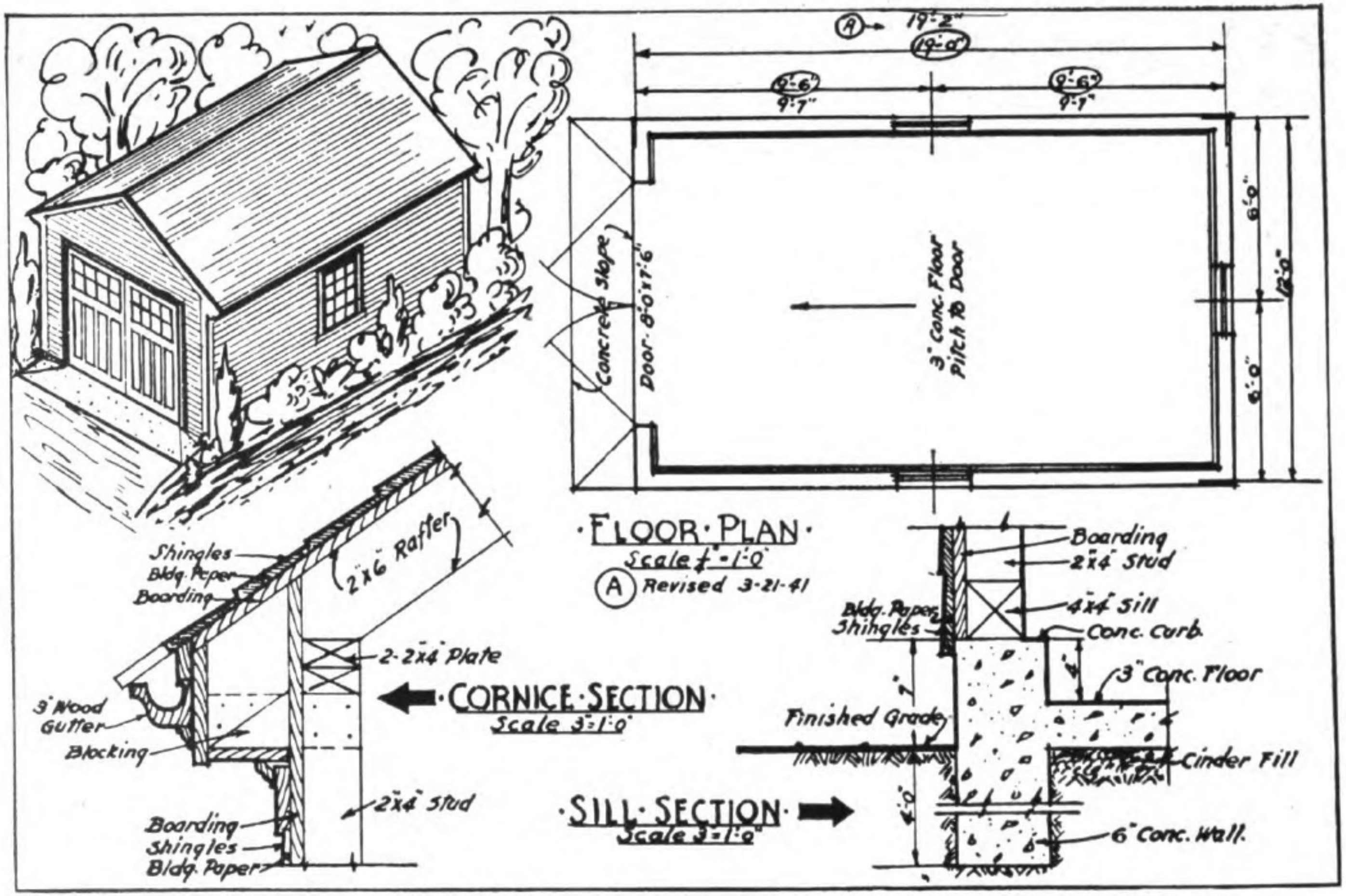
balloon framed building a fire trap. The frame can be modified to obtain greater rigidity by use of heavier lumber in sills and joists, and by introducing horizontal bridging between the studs in the outer walls. One by six braces cut diagonally into the studs from sill to corner post, as shown in figure 24, will also add greatly to the strength of the frame.

Platform framing, or western framing as it is sometimes called, is the second type of framing that you will encounter (see fig. 24). In platform framing the sills are first put in place as in balloon framing. The joists are spiked to the sill and then the subfloor is laid on top of the joists to create a platform. This provides a safe convenient place on which to raise the side walls and center bearing partitions. The studs of inside partitions and outside walls are cut to the same length and the erection of partitions and side walls is similar. Each floor and each wall can be built as a separate unit. The studs do not need to be notched for a ribbon as in the balloon frame. The same length studs may be used for all walls and partitions throughout the house unless the ceiling heights vary. Also one pattern may be used for all the main joists of the building. Platform framing is especially adaptable to prefabrication. When a number of identical buildings are to be constructed the studs, joists, walls, rafters, etc., may be cut by power tools and in some cases nailed into panels for erection on the building site.

FRAMING DETAILS

From the preceding description of framing terms and types of frames you should have a good idea of the general construction of a wood building. Before you actually start work on a framing job you will require specific information on a number of the details of the construction. This information is contained in the blueprints (working drawings) and specifications (specs) for the building. Specific information on framing is found in the framing details which are a part of the working drawings.

Figure 25 is the working drawing for a wooden garage. As you study this drawing you will notice at the bottom of the



—Courtesy of McGraw-Hill Book Co., Inc.

Figure 25.—Working drawing for wood garage.

drawing two smaller drawings labeled cornice section and sill section. Let's look at the sill section a moment and see what we can learn about the construction of this garage. The sill is a solid 4 x 4 timber which supports 2 x 4 studs. Board siding is nailed to studs and then covered with roofing paper and shingles. The details of the foundation are also shown in this drawing.

The cornice section (fig. 25) gives further information you will need to construct this garage. By studying this drawing you can see that the rafters are 2 x 6's and the plate is made up of two 2 x 4's. The details of roof and gutter construction are also given in this framing detail. You probably won't ever frame a garage like the one shown in figure 25, but you will eventually be on a job which requires framing and the ability to read framing details.

DETAILS OF CONSTRUCTION

In the previous discussion of framing members no mention was made of the details of construction of these members. These details of construction will appear in the blueprints and framing details. You should know at least a few of the methods commonly used in the construction of framing members.

SILLS

As we have said, sills are the first members of a frame to be placed. They rest directly on the foundation and extend all around the building. They are spliced where necessary and joined together at all corners. There are four types of sills: laminated, solid, lapped, and box.

The LAMINATED SILL is made up of two or more timbers set on edge and spiked together to make the sill strong enough to bear the structure. These laminations should be staggered at the joints, as shown in figure 26A.

A SOLID SILL consists of one piece of timber. (See B, fig. 26.) This type is preferred over the laminated sill because of the added strength and easy and quick installation. All joints in the solid sill should be halved. You should join solid sills

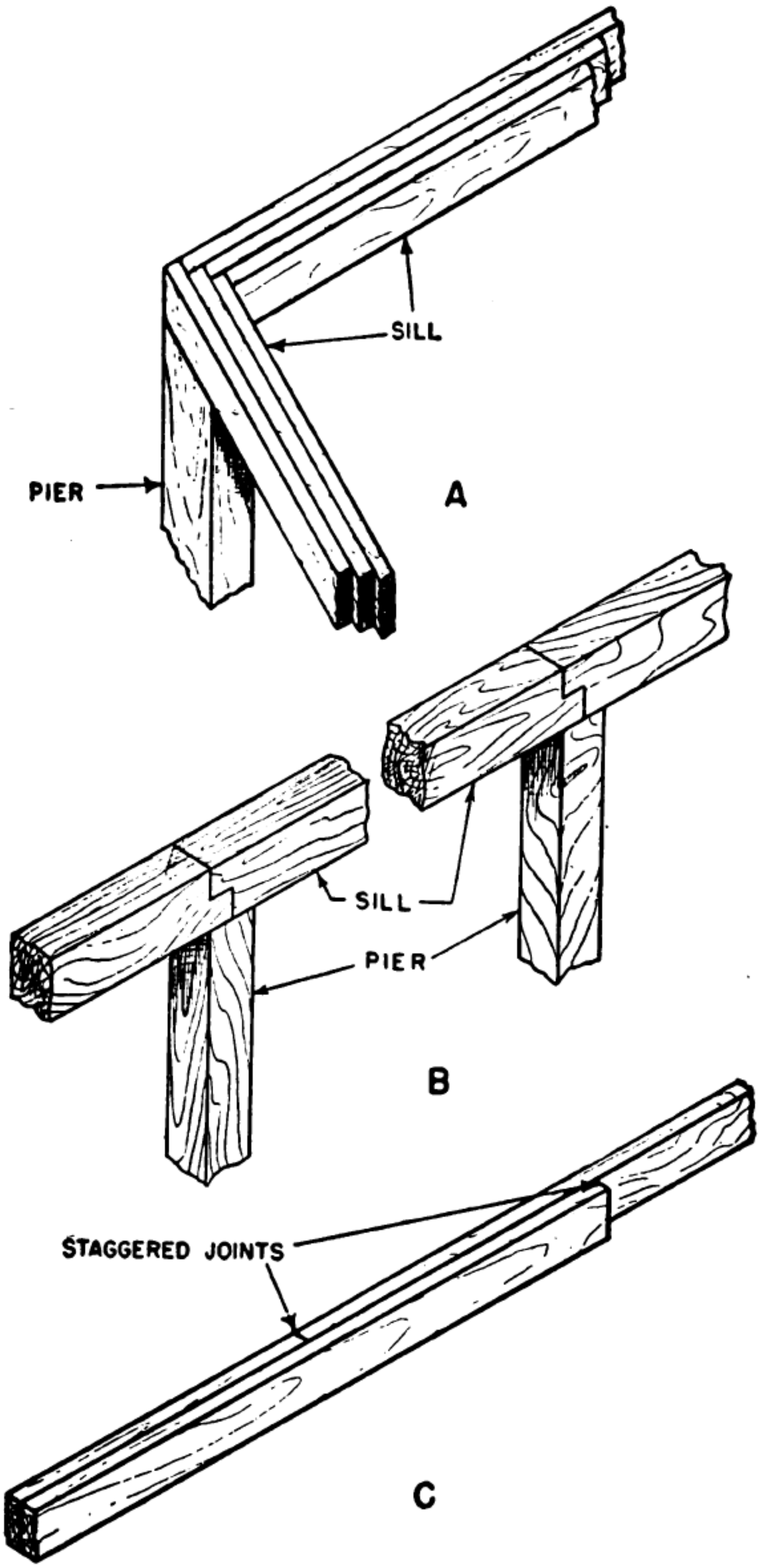


Figure 26.—A. Staggered laminated-joint sill. B. Solid sill. C. Lapped sill.

directly over the foundation piers if the structure is supported by this type of foundation.

A LAPPED SILL is made up of two members laid flat on a solid foundation. Its primary purpose is to receive the floor joists and serve as a nailing surface for the outside sidewalls and header blocks between the floor joists (see C, fig. 26).

The BOX SILL is generally used when continuous foundation walls support the structure. This sill consists of two pieces of wood. One rests flat on the foundation and is called the SILL PLATE, while the other piece is laid edgewise on the outside edge of the sill plate. The three methods of box sill construction are shown in figure 27.

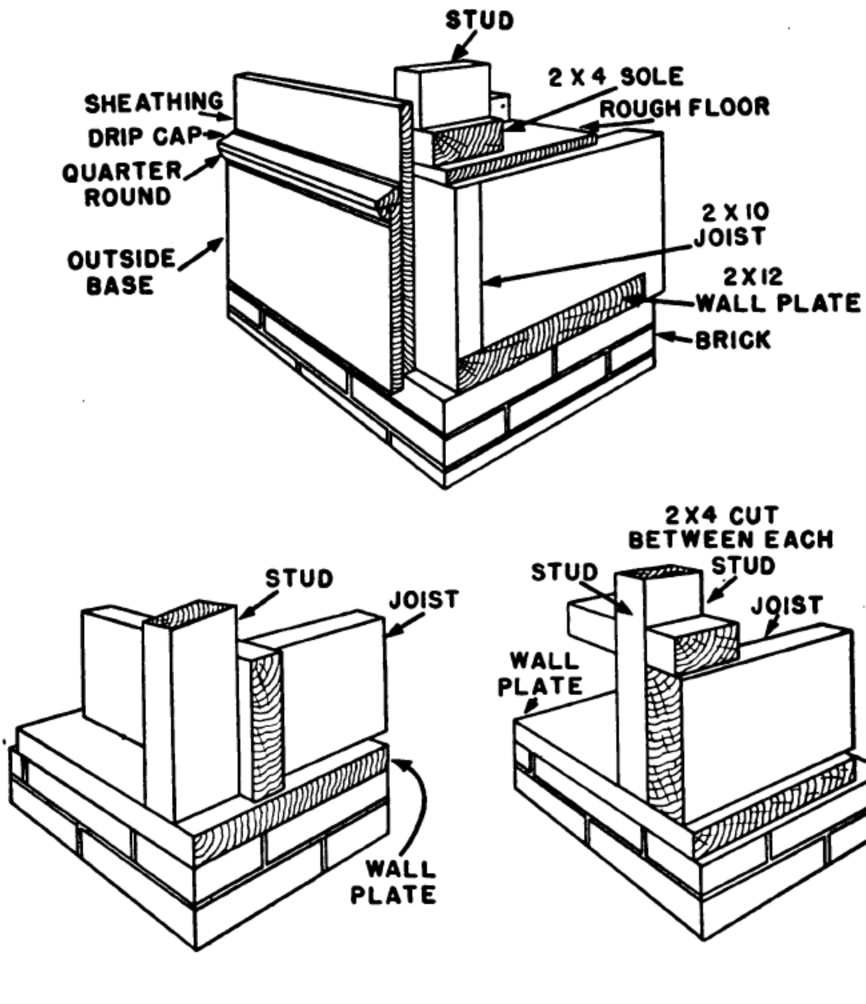


Figure 27.—Three methods of box sill construction.

On solid foundations, the sill is the means of joining the structure to the foundation. In most cases, particularly in light frame structures, anchor bolts are set into the masonry at intervals of from 8 to 10 feet. These bolts extend up through holes bored in the sill and are fastened at the top of the sill with a nut screwed down tight on a washer, thus fastening the sill, and the whole frame, securely to the foundation. When the sills rest on a concrete foundation, a couple of coats of linseed oil or wood preservative should be applied to the underside of the sill to keep it from absorbing moisture from the masonry.

JOISTS

JOISTS are usually single boards and are not built up as are sills. Nails and spikes are commonly used to join joists to sills. Joists are supported at one or both ends on the sill. A COMMON JOIST is one that extends from one sill to the other and helps support the uniform load. A CARRYING JOIST is one that extends and is spaced directly under a partition. Carrying joists are usually placed in pairs, spaced about 4 inches apart, to carry the added weight of the partition. These two joists should be far enough apart to project a little on each side of the partition, as shown at A in figure 28, to give a nailing surface for the finished flooring. Plank or solid bridging should be placed between such joists at intervals of from 14 to 20 inches to stiffen them. However, the subfloor is often put in place as soon as the joists are laid. Then, the carrying joists are doubled and spiked together, forming one unit.

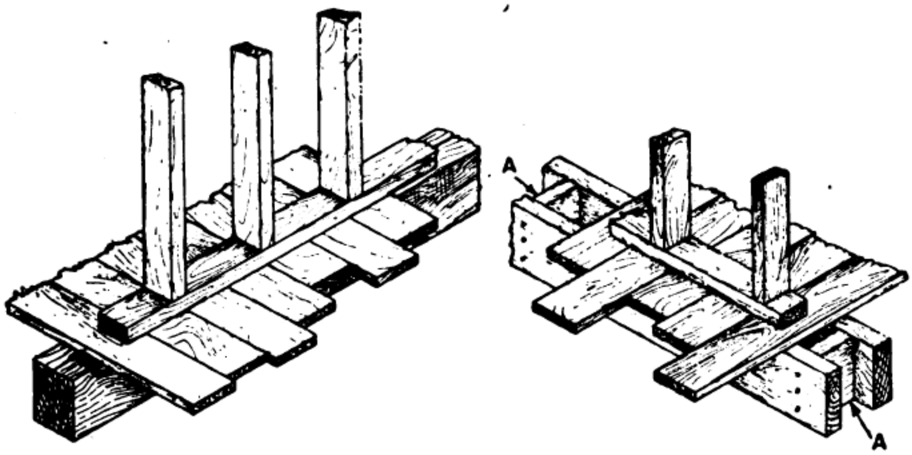


Figure 28.—Partition joist support.

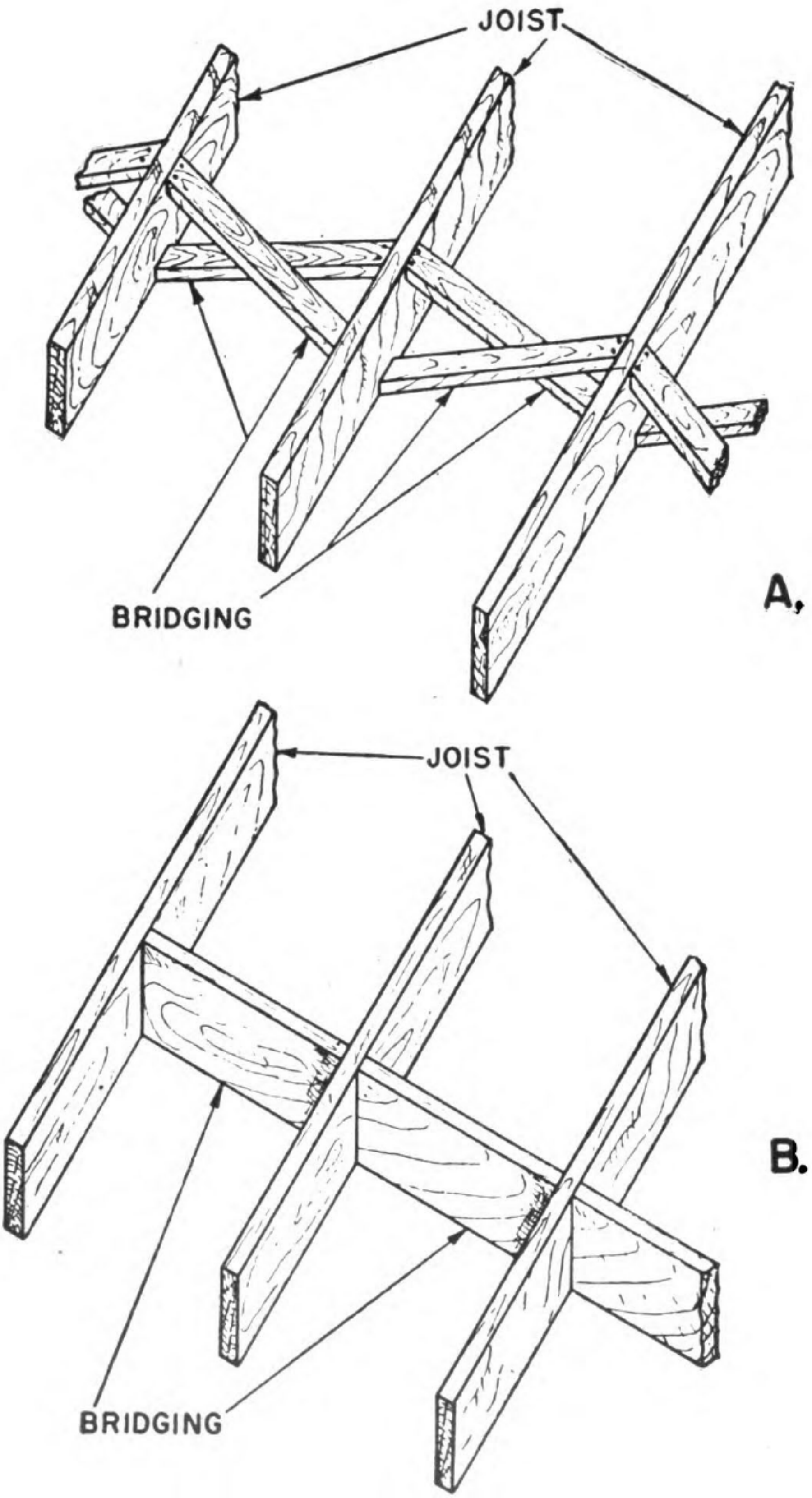


Figure 29.—Bridging—A. Cross bridging. B. Solid bridging.

In order to prevent joists from springing sideways under a heavy load, bracing called bridging is nailed into place. Figure 29 shows two kinds of bridging.

Herringbone or CROSS-BRIDGING is preferred for use in floor frames to stiffen the frame, prevent unequal deflection of the joists, and enable an overloaded joist to get some assistance from the joists on either side of it. This diagonal bridging consists of pieces of scantling, usually 1 x 3 inches or 2 x 3 inches in size, nailed diagonally between the floor joists, as shown in figure 29. Each piece is nailed to the top of one joist and to the bottom of the next joist; and the two pieces which cross each other are placed close together between the same two joists, forming a cross. Bridging should be placed in straight lines at intervals of 8 or 10 feet, forming continuous trusses across the whole length of the floor. When possible, only the top of the bridging should be nailed first, then when the joists have adjusted themselves to their final position, the lower ends of the pieces of bridging are fastened in place against the joists from underneath.

SOLID BRIDGING is made by placing small blocks of the same width as the joists between the joists. They are placed in a vertical position, tying the joists together so that loads will be evenly distributed.

FLOORS AND SUBFLOORS

After the joists are in place, the subflooring and flooring are usually laid, especially in buildings using platform framing. All subflooring should be laid diagonally to the joists to give additional strength to a structure. Then finished flooring should be laid at 90° to the joists. This insures better nailing, as the finished flooring is nailed through the subflooring into the floor joists themselves. Ordinarily 6-inch tongue and groove sheathing is used. The same kind of material is used for subfloors that is used for exterior sheathing. Subflooring may be laid either before or after the walls are framed, although it is better to lay it before, so that it can be used as a deck to work on while framing the walls.

CORNER POSTS

After the sill, first-floor joists, and the subflooring are in place, the next building step is to construct the corner posts. The corner posts may be made in three different ways (see fig. 30).

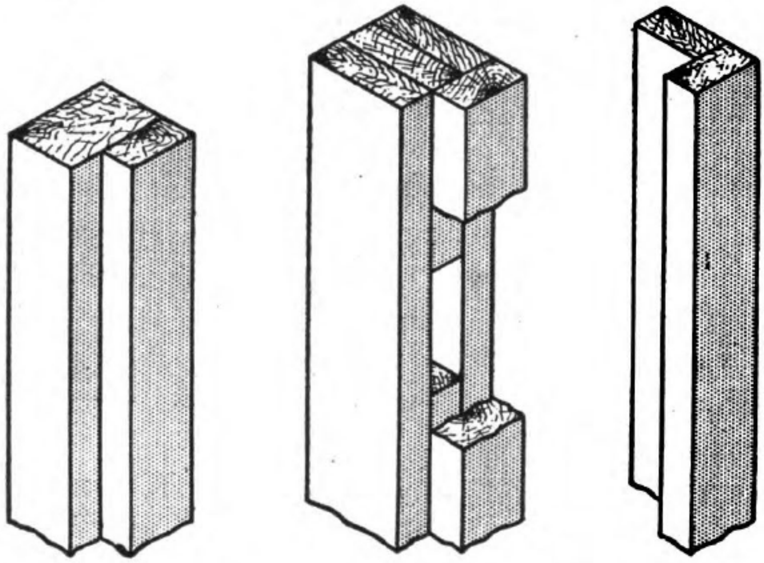


Figure 30.—Corner post construction.

You'll observe that the first post consists of a 4 x 6 with a 2 x 4 nailed flush with one edge on the broad side. This type should be used when putting in a 4-inch sidewall. Heavier timber should be used for a thicker wall. The second post consists of two 2 x 4's with blocks between them and a 2 x 4 nailed to the flush edge of one of the previously mentioned 2 x 4's. A third post may be made by nailing one 2 x 4 to the edge of another. The edge of one is placed flush with the side of the other. This type is generally used where no interior finish is required, such as for field construction in advanced areas.

T-POSTS

When a partition meets an outside wall, a stud called a T-post must be installed. T-posts should be wide enough to extend beyond the partition on both sides so as to furnish a solid nailing base for the interior wall finish. The T-post may be made in four different ways (see fig. 31).

A. A 2 x 4 may be centered and nailed on the face side of a 4 x 6.

B. A 2 x 4 may be centered and nailed on two 4 x 4's nailed together.

C. Two 2 x 4's may be nailed together with a block between them and a 2 x 4 centered on the wide side.

D. A 2 x 4 may be centered and nailed on the face side of a 2 x 6, with horizontal bridging nailed behind them to give support and stiffness.

In cases where partition walls cross, you should use a double T-post. Double T-posts are made simply by nailing another 2 x 4

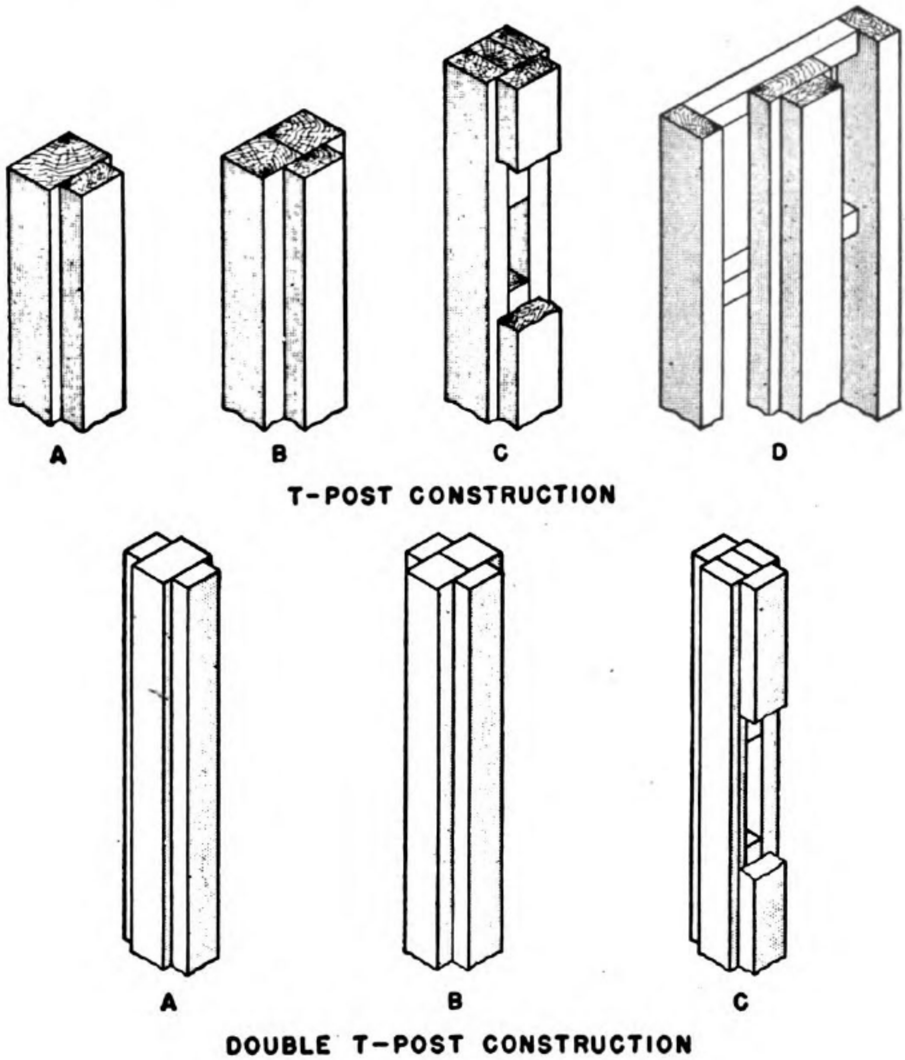


Figure 31.—T-post construction and double T-post.

to the opposite wide side of T-posts made by methods A, B, or C in figure 31.

LEDGER PLATE

A LEDGER PLATE is a member nailed to the face of the sill or girder, flush with the bottom edge. This ledger plate serves to connect joists to girders and sills where piers are used for foundations. The ledger plate is secured to the sill or girder by 20-penny nails about 12 inches apart. When the floor joists used in a structure are 2 x 4's, 2 x 6's, or 2 x 8's, it is well to use 2 x 2's for the ledger plates, so as to prevent the joists from splitting at the notch. When the joists are 10 inches deep or deeper, you can use 2 x 4's for ledger plates without reducing the strength of the joists. In cases where a notch is used, you should use joist ties, as shown in figure 32, to overcome this loss of strength.

PLATES

The top plate serves three essential purposes: (1) To tie the studding together at the top and form a finish for the walls;

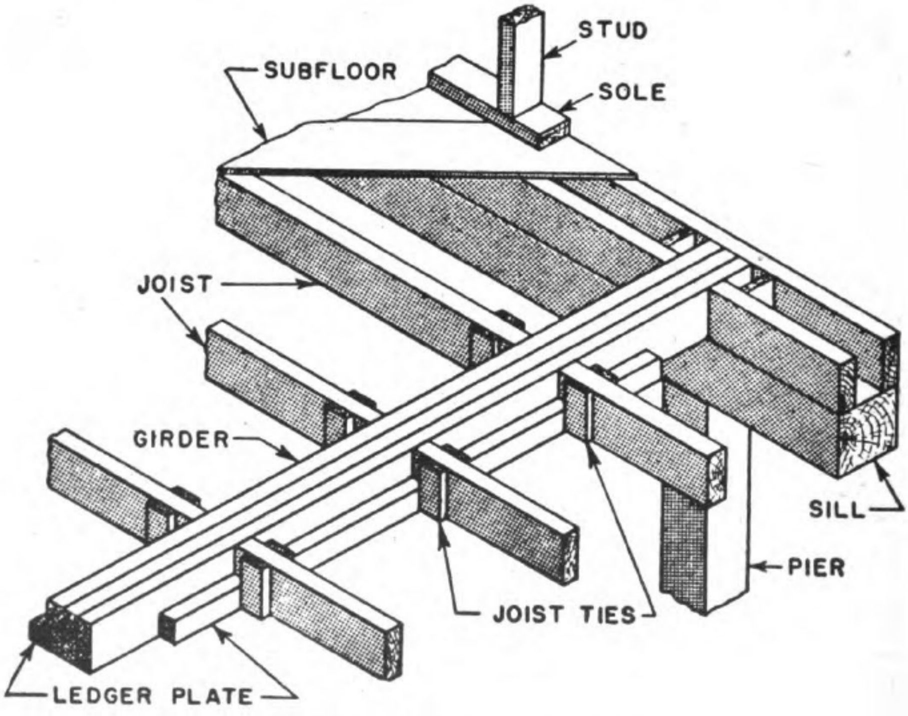


Figure 32.—Floor framing.

(2) to act as a support for the lower ends of the rafters; and (3) to support the ceiling joists.

The top plate serves as a connecting link between the wall and the roof, just as the sills and girders are connecting links between the floors and the walls.

The plate should be made with one or two pieces of timber of the same size as the studs. Frequently top plates are doubled. A double plate is made by nailing the first plate or bottom section to the top of the corner posts and to the studs, the connection being made at the corner as shown in figure 33. Secure the single plate and corner braces in place. Then nail the top part of the plate to the bottom section in such a manner that the edges of the top section are flush with the edges of the bottom section. Lap the corner joints as shown in figure 33.

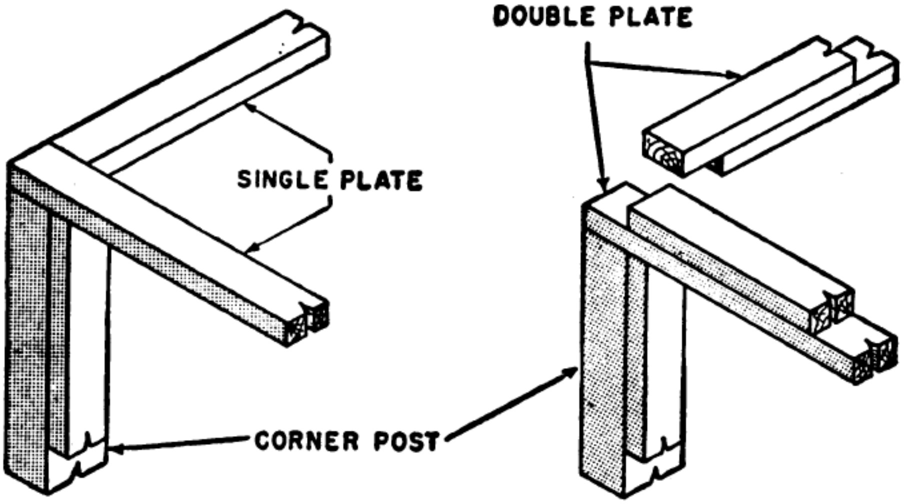


Figure 33.—Plate construction.

A sole plate is a 2 x 4 or timber that carries the bottom end of the studs. The sole plate is laid horizontally on the floor or joists. All partitions and outside walls should be finished with a sole plate corresponding to the thickness of the wall.

BRACES

Braces should be installed in the framing wherever the sills, girts, or plates make an angle with a corner post or with a T-post in the outside wall. Braces serve to stiffen the walls, keep the

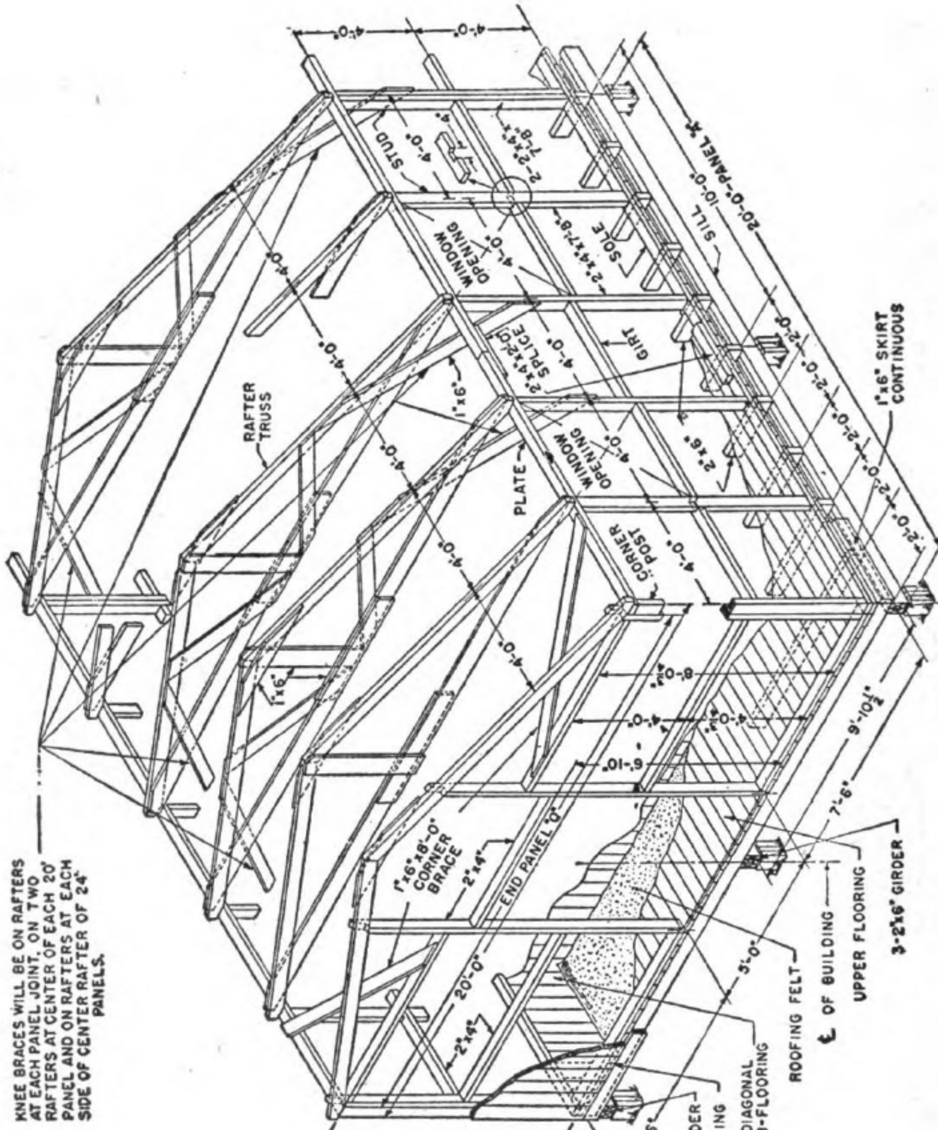


Figure 34.—Structural framing.

corners square and plumb, and prevent the frame from being distorted by a lateral force, such as wind. Braces should be placed so that they extend from the sill or sole plate to the top of the plate or post. Install them at an angle of 60° with the sill or sole and at an angle of 30° with the post. Braces placed between the studs should always be of the same size material as the stud. In advanced base construction, GIRTS are used where the outside walls are covered with vertical sheathing or siding. Girts should be made of material of the same width as the studs, and placed flush with both the inside and outside face of the stud. Studs are placed from 1⅓ to 12 feet apart, with girts spaced about four feet apart, running horizontally between them (see fig. 34). Vertical siding helps to carry the weight of the roof along with the studs.

In frame construction, where time permits, braces should be notched into the structural members and spiked in place. Notched studs make the best braces. This type of bracing is called LET-IN bracing (see fig. 34).

After the sills are in place, the framing of the wall can be completed. Window and door openings should be laid out according to the architect's plans and specifications. Then the studs are laid out on the soles by measuring from one corner the distances the studs are to be set apart.

PARTITIONS

PARTITIONS divide the interior space of a building. They are usually framed as part of the structure. However, in cases where floors are to be installed after the outside of the building is completed, the partition walls are left unframed. There are two types of partition walls, the bearing type which supports overhead braces, partitions, or ceiling joists, and the nonbearing type which supports only itself. The nonbearing type may be put in at anytime after installing the other framework. Partitions are framed in the same manner as outside walls. The door openings in partitions should be framed in the same manner as outside door openings. Where there are corners, or where one

partition wall joins another, corner posts or T-posts should be used to provide nailing surfaces for the interior wall finish. When the plans and specifications call for the installation of wall or insulating boards for interior sidewall finish, the studding should be placed 1⅓ feet apart. This provides more nailing

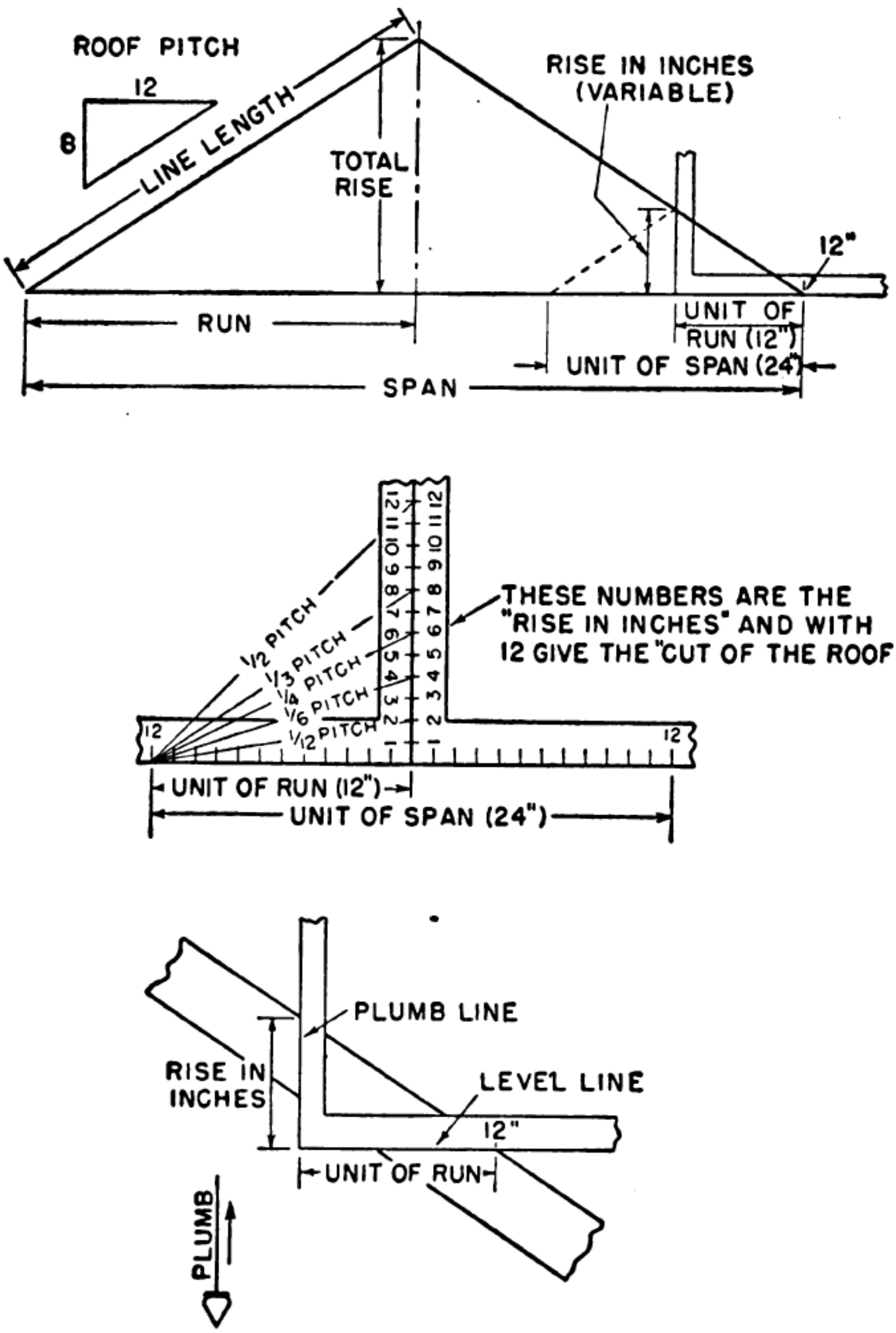


Figure 35.—Rafter lay-out terms.

surface and helps keep the wall or insulating board from warping or buckling.

RAFTERS

RAFTERS are the structural members that support the roof. Framing hip and valley roofs is a rather complicated process and, since the most commonly used roofs in military construction are the shed and double pitch roofs, this discussion will be limited to the rafters required for these types of roofs.

Before you can begin to learn about roof framing, however, there are a number of terms with which you must become familiar. They are:

(1) The PITCH of a roof is the slope of the roof surface. It is the angle which the roof surface makes with a horizontal plane. The roof pitch is expressed by numbers, for example: 8 and 12. Eight is the rise and 12 the run. On blueprints, the pitch is shown as in figure 35.

(2) The SPAN of any roof is the shortest distance between the two opposite rafter seats.

(3) The TOTAL RISE is the vertical distance from the plate to the top of the ridge.

(4) The TOTAL RUN refers to the level distance over which any rafter passes or one-half the span of the roof.

(5) The UNIT OF RUN, or the UNIT OF MEASUREMENT, 1 foot or 12 inches, is the same for the roof as for any part of the building. Using this common unit of measurement, you can employ the framing square in laying out roofs as shown in figure 35.

(6) The RISE in inches is the number of inches that a roof rises for every foot of run.

(7) The CUT OF A ROOF is the rise in inches and the unit of run as indicated in figure 35.

(8) The term LINE LENGTH, as applied to roof framing, is the hypotenuse of a right triangle whose base is the total run and whose altitude is the total rise (see fig. 35).

(9) The PLUMB and LEVEL LINES refer to the direction of a line and not to any particular rafter cut. Any line that is vertical when the rafter is in its proper position is called a plumb line. Any line that is level when the rafter is in its proper position is called a level line. Refer to figure 35.

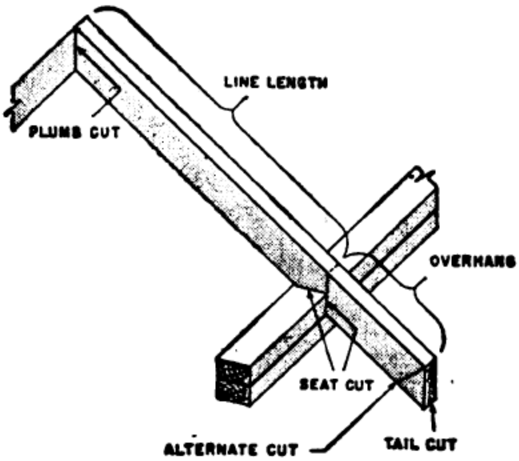


Figure 36.—Rafter terms.

There are three kinds of rafter cuts as follows (see fig. 36):

1. The RIDGE or PLUMB CUT which is the cut that fits against the opposite rafter at the ridge.
2. The SEAT CUT which is the notch cut in the rafter to fit it to the plate.
3. The TAIL CUT which is the cut at the lower end of the rafter.

There are several methods of laying out rafters. The measured step off method is the simplest method. It makes considerable use of the framing or carpenter's square. The short leg of the square is called the tongue and the long leg is the blade.

Suppose you are framing the rafters for a building 20 feet wide. The roof is to have a rise of 8 inches per foot.

To find the length of the rafter to be used, first determine one-half the distance between the outside edges of the plate. Since it was assumed that the building was 20 feet wide this distance (the run) would be 10 feet. Remember this 10 feet—

you will have to use it later. Now measure the diagonal distance (line length) between 8 inches on the tongue of the square and 12 inches on the blade. This distance is $14\frac{5}{12}$ inches. The reason you measure the distance between the 8-inch and 12-inch marks is because the rise is 8 inches and the unit of run is 12 inches. Now multiply that $14\frac{5}{12}$ inches by 10 which is the span of the rafter. The result of this multiplication should be $144\frac{2}{12}$ inches or 12 feet $\frac{1}{6}$ inch which is the length of the rafter disregarding overhang.

After the length of rafter is determined you are ready to lay out the cuts. To lay out the plumb cut, place the rafter material on saw horses, hold the square with its tongue in your right hand, its blade in your left, and the heel (the place where tongue meets blade) away from you. Place the square on the material with the 8-inch mark on the tongue, and the 12-inch mark on the blade along what is to be the top edge of the rafter. Marking along the tongue edge of the steel square will give complete marking of the seat cut.

To mark the seat cut, you measure the length of the rafter 12 feet $\frac{1}{6}$ inch from the top of the plumb cut. Now, holding the square in the same position as for the plumb cut, with the 8-inch mark on the tongue directly over the 12-foot $\frac{1}{6}$-inch mark, mark along the tongue of the square. Slide the square down the rafter till the blade intersects the mark just drawn. Mark along the blade of the square to complete marking the plumb cut. The tail cut may be square or plumb cut.

After the rafters are laid out and cut to size they are usually assembled into trusses. Two rafters are connected at the top by a collar tie nailed onto both rafters. Before any ties or chords are made fast, the rafters should be spread out at the lower end to correspond to the width of the building. This may be done by using a template, or by measuring the distance between the seat cuts with a tape. A chord of 2 x 6 is nailed across the rafters at the seat cut to tie the rafters together. This chord forms a truss with the two rafters. A vertical member of 1 x 6 is nailed to the rafter joint and this extends to the chord at midpoint, thus securing the rafter to the chord. If no additional

bracing is needed, then the pair of rafters is put in place on the plates. If additional bracing is required, a knee brace is used. The knee brace should form an angle of 45° with the wall stud. Another brace is nailed to the rafter at its midpoint; this brace extends to the chord at its midpoint as shown in figure 37.

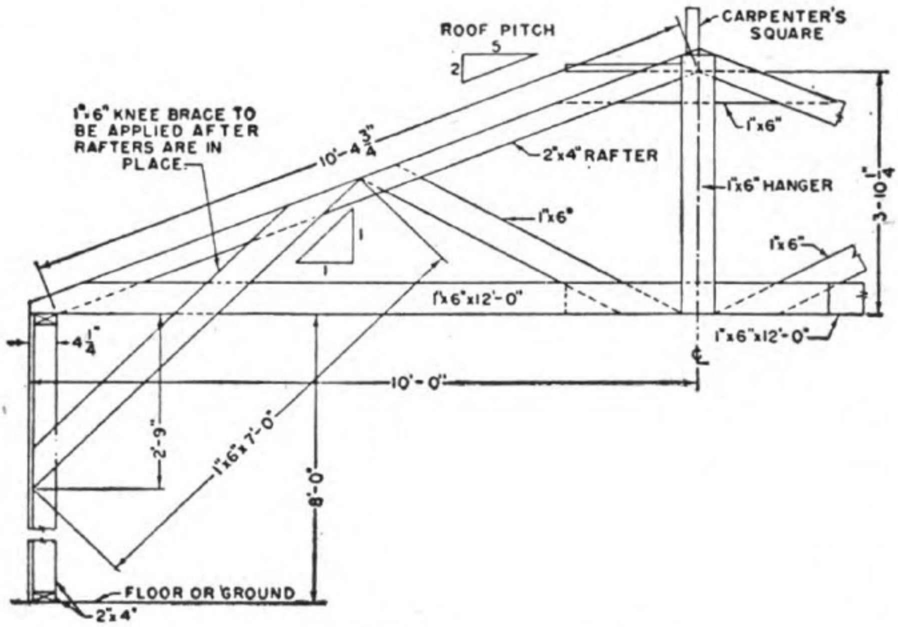


Figure 37.—Rafter construction detail.

To speed erection, the knee braces may be omitted until the rafter truss is set in place. After the rafters are assembled into trusses, the next operation is the placing of the trusses on the building. Generally, the set of rafters in the end section of the building is assembled first. The rafter trusses are raised into position by hand and fastened to the plate with 16- or 20-penny nails. These trusses should be temporarily braced to the end section of the building, until the roof sheathing is applied.

With the erection of the rafters the frame of the building is complete. The sides and roof, if not sheathed as the building is constructed, are then sheathed, and the outside finish is applied to the sheathing to complete the building.

FRAMING SAFETY

If you are in charge of a job that involves carpentry you should know the safety precautions that apply to this work. See

that the men you are supervising know and observe the following safety rules:

1. Nails must be removed from temporary bracing when the bracing is removed.
2. The frame must be braced securely before any personnel are allowed to go out on it.
3. All sharp-pointed or sharp-edged tools must be properly sheathed before being placed in pockets.
4. All frames should be securely braced before closing down the job for the day. Also, all ladders should be taken down.
5. A temporary deck should be laid on the joists to provide a safe working platform.
6. A catwalk should be installed across the ceiling joists to aid in pulling rafters or trusses in place.

HEAVY CONSTRUCTION

Not all the wood construction done by the Seabees is the light construction described in the preceding pages. Water front construction in particular involves the use of heavier structural members than those ordinarily found in frame buildings. These heavier members are called timbers. By definition a timber is a piece of lumber that is over five inches thick.

Just as the lumber in light framing is designated according to its place and function in the building, timber structural members are also designated according to their function.

To understand the nomenclature of timber construction take a look at the typical pier in figure 38. This pier is supported by piling. After the piles are driven and sawed to the same height, beams are placed across them and fastened in place. These transverse beams are called cap sills. The stringers are the longitudinal timbers that are secured to the cap sills. The floor is nailed to these stringers. Heavy timber may be used for the flooring or two layers of lighter lumber may be used as a substitute for the heavy timber. Timber braces are used to tie the piles together and to give the pier greater rigidity. A fender of heavy timbers is placed the length of the pier and secured to the piles at

a point above high water. This timber protects both ships tying up and the pier.

Timbers are used in other military construction such as culverts and bridges. In general, the terms used to designate the structural members making up these structures are the same as those designating corresponding members in pier construction.

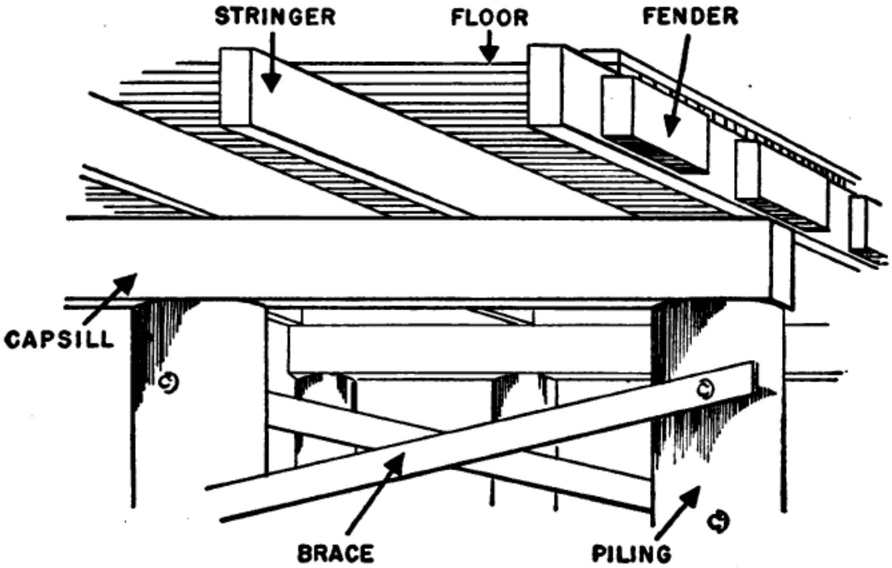


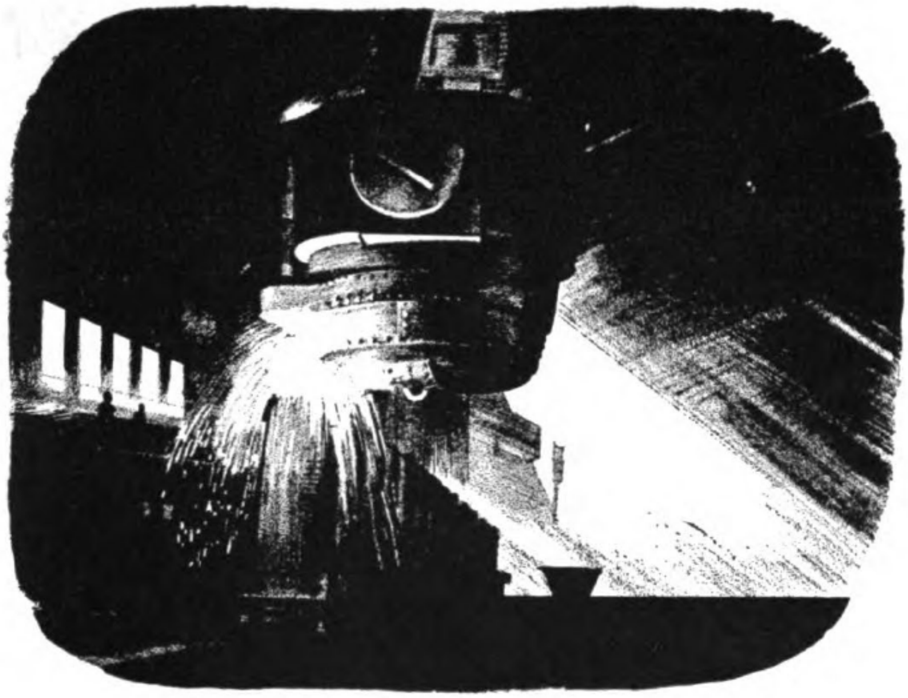
Figure 38.—Timber pier.

You are not a Builder just because you have read this short chapter on building and have perhaps been on several jobs that involved simple carpentry. Don't begin to think the job of the Builder is a cinch. Before you can assume the duties required to become a warrant, you will have to gain a great deal of on-the-job carpentry experience and burn a lot of midnight oil on intensive study.

The Navy Training Course, *Builder 3 & 2,* NavPers 10648-A, will give you a good foundation in carpentry.

QUIZ

1. What is the framing member that rests on the foundation and forms a bearing surface for the outside of a building called?
2. What is the function of the joists?
3. What are the vertical framing members to which outside walls are nailed?
4. What are the members that support the roof of a building?
5. Name two types of light-wood framing commonly used in Navy construction.
6. What type of framing is especially suited to prefabrication?
7. Name four types of sills.
8. What name is given to a joist that is spaced directly under a partition?
9. When a partition meets an outside wall a special stud must be installed. What is this stud called?
10. The top plate serves three essential purposes. What are they?
11. In roof terminology, what is the shortest distance between two opposite rafter seats?
12. What terminology is applied to the notch in the rafter which makes it fit the plate?



CHAPTER 4

STEEL

YOUR MATERIAL

Have you ever gone through Pittsburgh at night? The Bessemer converters shoot their fireworks into the night sky and steel is born. Three months to a year later you may have that same steel in your hand in the form of a wire rope, a bolt, or a wrench. Or it may be in a warehouse in the form of shapes and plates waiting for your skill as a Steelworker to turn it into a tower, tank, or Butler building.

Have you ever wondered—What goes into steel? How is it made? Why do some steels bend and other steels break under the same conditions? How is steel formed into sheets, rods, beams and other shapes?

Steel is a wonderful material. If you have a better understanding of its properties you will be able to use it more effectively to carry out your duties as a Steelworker.

HISTORY OF IRON

No one knows exactly when iron was first used but we know that it was used by the ancient Hebrews and Assyrians as early as 1400 B.C. The Romans became quite proficient in extracting and shaping iron. At the time of the Roman occupation of Europe, the iron industry became important in England.

The early iron makers made iron by heating a mixture of ore and charcoal in a flat-bottomed furnace until a small quantity of pasty metal collected in the bottom of their crude furnace. They then took this metal from the furnace and worked it by hammering it into what today is known as wrought iron. This was the only known method of making iron until 1350, at which time the iron makers of Central Europe succeeded in producing molten iron. This they accomplished by building a furnace of masonry which enclosed an opening in the form of two truncated cones placed end to end. In a crude way this furnace resembled the modern blast furnace. In this furnace ore, flux, and charcoal were charged in at the top of the shaft while air was blown in at the bottom. In 1619, coke was first used instead of charcoal. Since then many refinements have been made in the equipment used to produce iron, but the basic process for separating iron from its ore has remained unchanged.

The iron obtained by blast furnace melting of iron ore is known as pig iron. Pig iron is the basic raw material from which all iron and steel products are produced.

PIG IRON

To produce pig iron, a mixture of iron ore, limestone, and coke is charged into a blast furnace (see fig. 39). The heat of the burning coke, together with the heat from the hot blast, causes certain chemical reactions by which the iron is produced. The end products of the chemical reactions in the furnace are slag and pig iron which are drawn off at the bottom of the furnace.

As you can see from table 1 pig iron contains other elements besides iron.

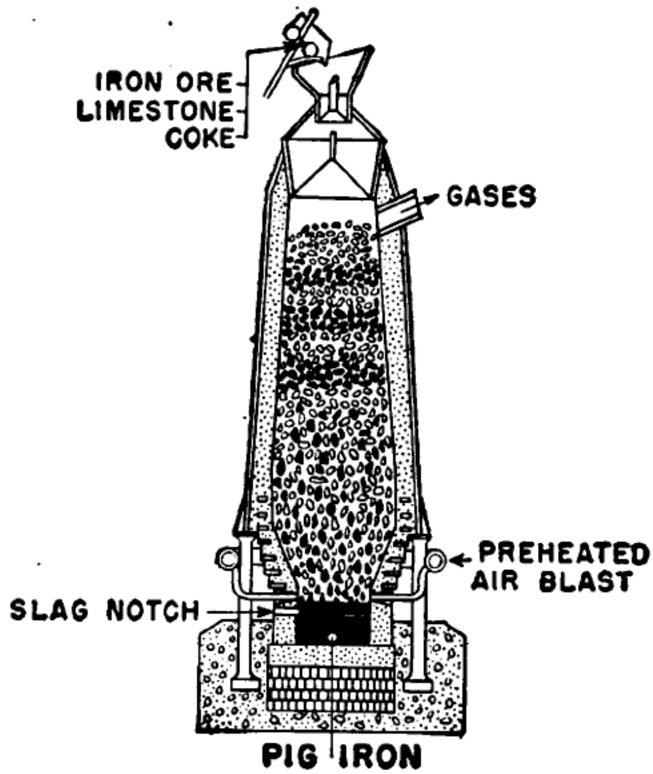


Figure 39.—Blast furnace.

Table I.—CHEMICAL COMPOSITIONS OF IRON AND STEEL PRODUCTS

Material	Percent carbon	Percent silicon	Percent manganese	Percent sulphur	Percent phosphorus
Pig iron......	3.00–4.00	0.50–3.50	0.50–2.00	0.02–0.10	0.03–1.00
Gray cast iron.	2.50–3.75	1.00–2.50	0.50–1.00	0.06–0.12	0.10–1.00
Malleable cast iron........	2.00–2.50	0.50–1.10	0.20–0.30	0.04–0.06	0.10–0.20
Ingot iron....	0.01–0.02	0.005	0.01–0.02	0.02–0.03	0.005
Wrought iron.	0.02–0.08	0.10–0.20	0.02–0.10	0.02–0.04	0.05–020
Carbon steel..	0.05–1.50	0.05–0.30	0.30–1.00	0.02–0.20	0.02–0.15

Pig iron is seldom used as it comes from the furnace since the large quantity of impurities in it give it properties that make it unsuitable for most purposes.

COMPOSITION OF STEEL

Steel is an alloy of iron and carbon together with other elements that are intentionally or unavoidably introduced into the metal during the manufacturing process. The properties of steel are dependent to a large extent on the chemical composition of the metal. Let's look at the other elements in steel besides iron.

CARBON has a greater influence on the mechanical properties of steel than any other element. As you can see by referring to table 1, steel is made up of from 0.05 to 1.50 percent carbon. In making steel for various purposes, the carbon content is accurately controlled. Table 2 lists the carbon content of steels

Table 2.—CARBON CONTENT OF STEELS FOR DIFFERENT USES

Carbon ranges percent	Uses of carbon steel
0.05–0.15	Pipes, chains, rivets, screws, nails, stampings.
0.15–0.30	Structural sections, plates, bars, carburized parts.
0.30–0.40	Axles, connecting rods, shaftings.
0.40–0.50	Chankshafts, gears, crane hooks.
0.50–0.60	Scraper blades.
0.60–0.70	Dies for drop hammers, set screws, locomotive tires.
0.70–0.80	Anvil faces, band saws, smithing hammers, rails.
0.80–0.90	Punches, rock drills, cold chisels, rivet sets.
0.90–1.00	Springs, axes, knives, shear blades.
1.00–1.10	Milling cutters, flat drills, taps.
1.10–1.20	Lathe tools, twist drills, wood chisels.
1.20–1.30	Files, reamers.
1.30–1.40	Wire-drawing dies, razors, brass-turning tools.
1.40–1.50	Saws for cutting steel.

for different uses. You can see that a steel with 0.80 to 0.90 percent carbon would be unsuitable for plates for a tank.

MANGANESE is used in the manufacture of steel as a refining agent to reduce the amount of oxygen in steel and to reduce the harmful effect of sulphur in the metal. Manganese causes an increase in tensile strength and is considered to be generally beneficial. The manganese content of carbon steels is usually less than 1.00 percent and commonly ranges from 0.30 to 1.00 percent.

SILICON is used in the making of steel to deoxidize and clean the molten metal. The amount of silicon which remains in the finished steel usually ranges from 0.05 to 0.30 percent and has no appreciable effect on the physical properties of the steel.

SULPHUR appears in steel combined either with the iron or with the manganese. When iron combines with the sulphur, a chemical compound called iron sulphide is produced. Iron sulphide has a low melting point and causes a lack of cohesion between the grains of steel when it is being worked hot. This results in weak steel at high temperatures. If the sulphur combines with manganese to form maganese sulphide the steel is not appreciably weakened since manganese sulphide has a higher melting point than iron sulphide. In many specifications for construction steels, the sulphur content is limited to 0.06 per cent. Steel used for tools usually has a sulphur content of less than 0.04 percent.

PHOSPHORUS combines with iron when the ore is smelted and is present in solution in the steel. In low-carbon steels (maximum 0.15 percent carbon) phosphorus raises the yield point and improves the resistance to atmospheric corrosion. The percentage of phosphorus in steels which must have favorable impact resistance is dependent upon the carbon content. The sum of the carbon and phosphorus usually does not exceed 0.25 percent.

The previous discussion deals with the composition of carbon steels. There is another class of steels called alloy steels. Alloy steels differ from carbon steels in that they contain percentages of nickel, chromium, vanadium, tungsten or high percentages of silicon and manganese. Most alloy steels are

special purpose steels and will not be discussed in detail in this book since most of your work as a Steelworker will be with carbon steel.

STEEL MAKING

By looking at table 1 you can compare the chemical composition of steel and pig iron. You can see that average pig iron contains too much carbon, silicon, manganese, sulphur, and phosphorus to make steel. To make steel from pig iron the metal must be refined so that the carbon and other elements are contained in the steel in definite quantities.

Steel has not always been the cheap and plentiful material it is today. Prior to 1856 only two methods of making steel, the cementation and crucible processes, had been developed. Both of these methods were slow and could not be adapted to making steel in the large quantities used today. However, crucible steel is still used in small quantities for special tools and other high-grade products.

Today most steel is manufactured by three processes. They are: (1) open-hearth, (2) Bessemer, and (3) electric furnace.

Let's look at these three methods. Since the basic open-hearth method is used to manufacture most steel used in this country, this method will be described first.

In the open-hearth process, pig iron and steel scrap are melted on a hearth by heat from the combustion of gaseous fuel. In some operations molten iron from a blast furnace is used instead of the pig iron and steel scrap.

Although there may be slight variations from one steel plant to another, the following description of steel making by the basic open-hearth method is typical of that generally used.

First, limestone is charged on the bottom of the furnace. Iron ore is charged on top of the stone, and steel scrap on top of this. If molten pig iron cannot be obtained in sufficient quantity to complete the charge, cold pig iron is charged with the scrap. After the charge of scrap and limestone is in the furnace, it is heated for about two hours or until the scrap is white hot and slightly fused. Molten pig iron is then added to make the total pig iron 50 percent of the charge. When the

molten pig iron is added a lively reaction takes place. During this chemical reaction almost all the silicon, manganese, phosphorus, and part of the carbon are burned out (oxidized). The silicon, manganese, and phosphorus combine with the slag and are drawn off with it at the end of about 3 hours.

The iron ore that was charged at the beginning of the heat continues to act on the carbon for three or four hours longer. During this time the limestone is being decomposed by the heat liberating carbon dioxide (CO_2). The carbon dioxide bubbles up through the molten metal exposing part of it to the flame in the furnace which completes the purification started by the ore reaction. What is known as the lime action or lime boil lasts 2 or 3 hours longer. At the end of this time, if the raw materials were charged in the correct proportions, the carbon content of the metal would be slightly higher than it should be when the metal is to be tapped. Generally, of course, the carbon is too low or too high and it is necessary to add more pig iron or ore to the melt to bring it to the specified carbon content. After another hour the carbon content will have been reduced to the proper content for tapping.

The second important method used in the making of steel is the Bessemer process. Of all the processes for purifying pig iron the Bessemer is the simplest. Essentially, it consists of blowing air under pressure through molten pig iron in a Bessemer converter. A converter as shown in figure 40 is constructed of a steel shell lined with refractory material. Air at ordinary temperature is blown through openings known as tuyeres in the bottom of the converter. Molten iron from a blast furnace is poured into the converter while it is tipped to one side. The air is blown through the tuyeres before the converter is turned to an upright position. When the air passes through the molten metal a violent chemical reaction takes place and practically all the silicon, manganese, and carbon are eliminated from the molten metal. However, considerable iron oxide and dissolved gas remain in the metal. Additions of iron alloys containing silicon, manganese, and carbon are made to the metal in the converter or as the metal is being poured from the converter. These alloys remove the undesirable

oxides and gases from the metal and at the same time supply the necessary proportion of these elements in the steel. The refining period requires only 12 to 18 minutes.

The electric furnace method of making steel is discussed briefly here since this method is for the most part confined to producing steels for special purposes. You will not ordinarily work with steels produced by this method.

In the electric furnace method steel is produced by melting steel scrap and high grade pig iron in a furnace, heated by electricity. The necessary materials are added to the molten metal to refine it and give it the required physical and chemical properties. This process can be controlled more closely than either the Bessemer or open-hearth processes and is extensively used to obtain high-grade tool steels.

Forming Steel Shapes

After being refined and brought to the specified chemical content, steel produced by any of these three methods is cast

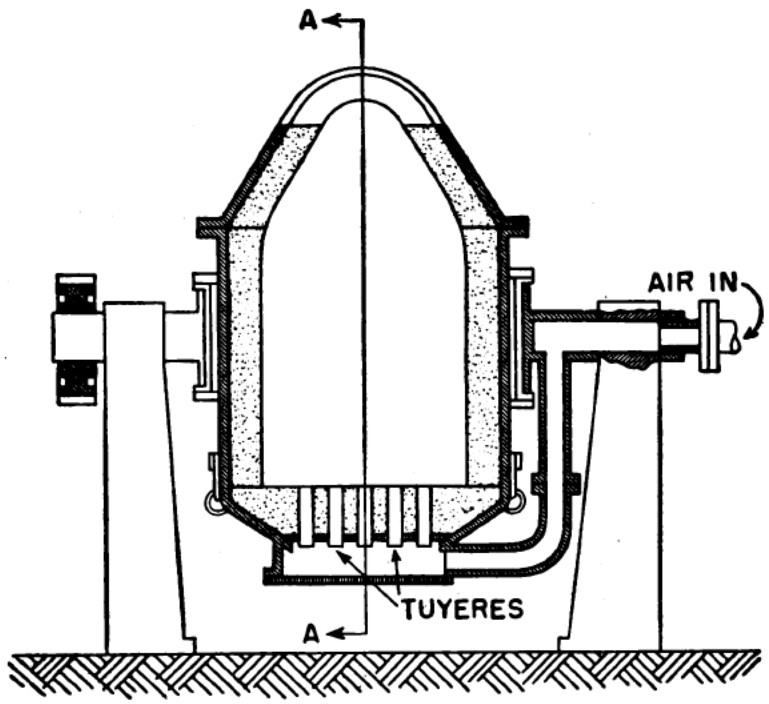


Figure 40.—Bessemer converter.

into ingots. The steel ingots must be shaped into plates or bars before they can be further fashioned into useful articles.

Ingot sizes vary from a few hundred to several hundred thousand pounds. A common ingot size is 6,000 pounds. There are two reasons for working the ingot steel. They are equally important. One is to improve the quality of the steel and the other is to form it into articles more suitable for use.

Mechanical shaping improves the quality of the metal by forcing its particles into more intimate contact and by refining its crystalline structure. When metal is worked its strength, ductility, and hardness may all be affected.

There are THREE MECHANICAL METHODS OF WORKING STEEL: hammering, pressing, and rolling.

HAMMERING was the first method employed by man to shape metals. Hammer forging is still an important method of shaping steel. Such articles as connecting rods, wrenches, engine valves, crankshafts, and bolts are a few items commonly forged. Driving hot rivets is a common forging operation. For the most part, steel stock used for forging articles is the product of rolling mills.

Another method of forming steel is by PRESS FORGING. In this method of forging, the steel is heated to the forging temperature and then subjected to great pressure in a hydraulic press. This method of forging is used to make armor plates, large gun barrels, and similar articles.

The most important method of shaping steel is by ROLLING it. The hot working begins with the reduction of ingots which have been heated in soaking pits to the desired rolling temperature. The ingots are rolled in blooming mills between two grooved rolls, one directly above the other as shown in figure 41.

The space between the rolls can be adjusted and the direction of the rolls can be reversed for alternate passes through the rolls. On a two-high blooming mill (one with two sets of rolls) an ingot about 23 inches square in cross section can be rolled down to a bloom (rolled ingot) 6 inches square in cross section, increasing the length proportionately in about 17 passes. This process requires about 2 minutes. After the bloom passes through the rolls for the last pass it goes to the shears where the top of the ingot is cut off and the bottom is squared.

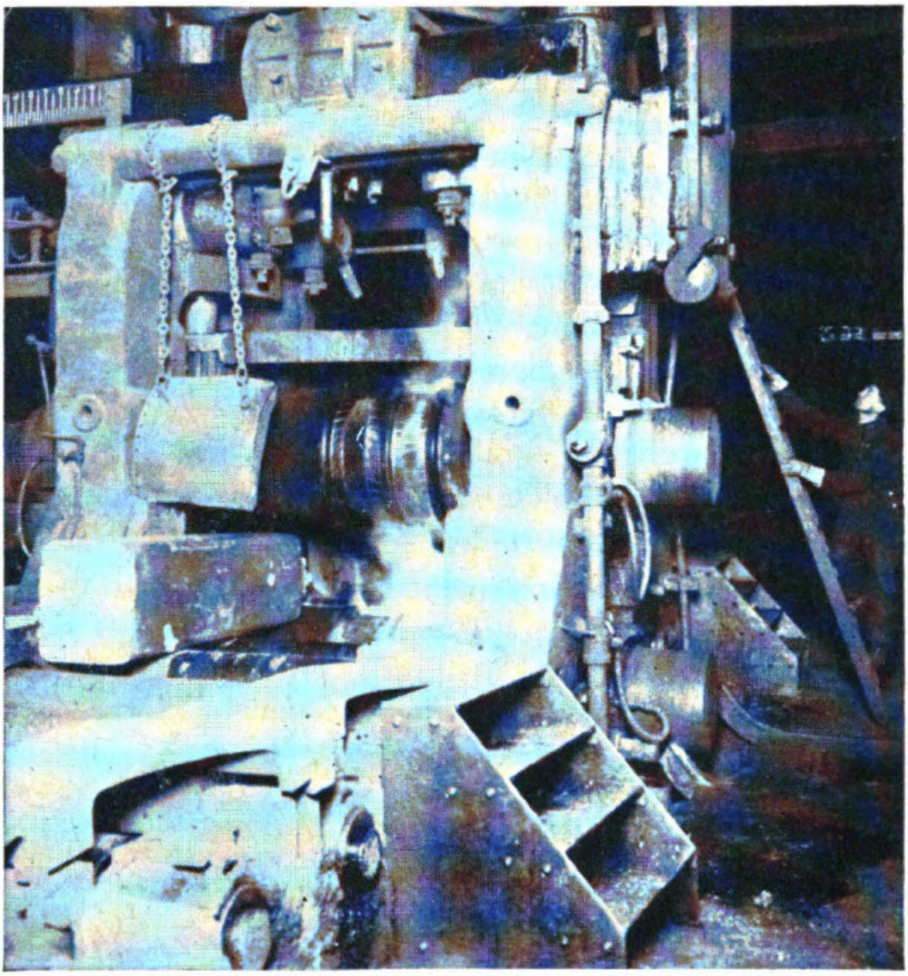


Figure 41.—Blooming mill.

When the bloom is to be used for bars, it is further reduced in size by passing through another series of rolls known as a billet mill. The billet is then cut into shorter lengths which are reheated for further rolling in the bar mill.

To manufacture plates, ingots are first reduced in size on slabbing mills into long flat pieces of steel. After the ends are cut off, the product from the ingot is then cut into slabs of suitable size for the plate mill. The slabs may be conveyed directly to the plate mill or may be stored for reheating. Slabs are rolled into plates on a plate mill as shown in figure 42. When the plate has been rolled to the desired thickness and then straightened, it is cut into plates of the required dimensions.

Sheet steel may be produced in the same manner as plate

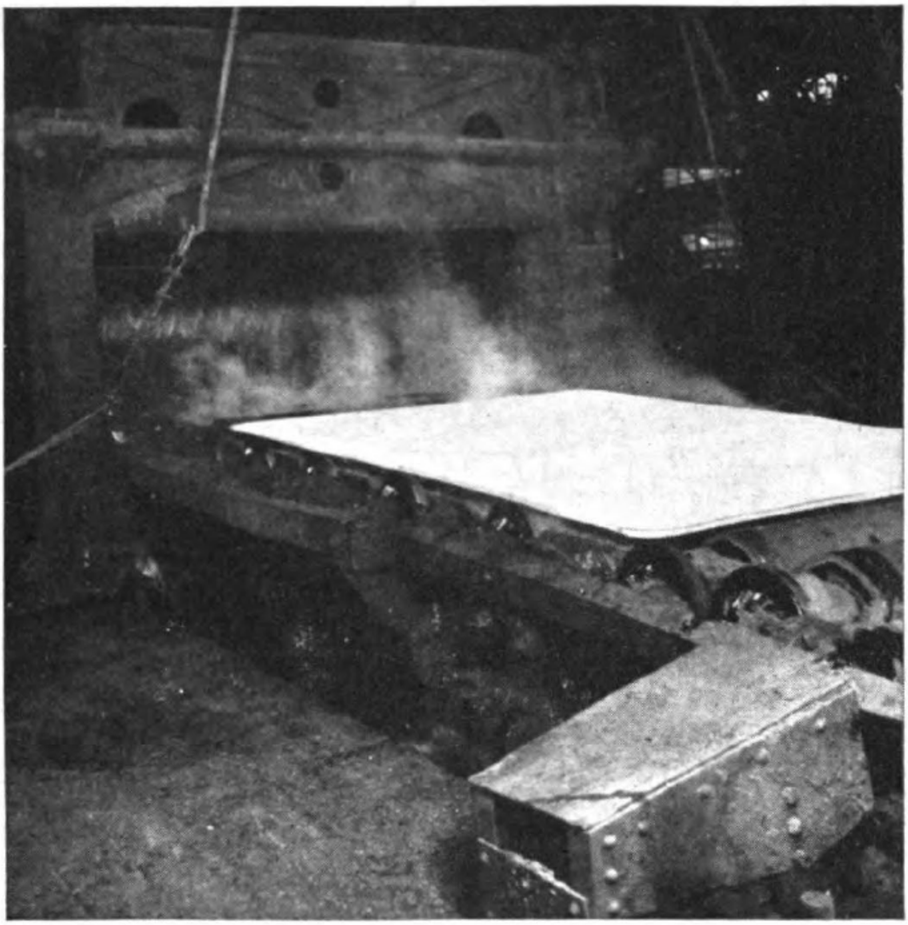


Figure 42.—Plate mill.

steel by continued reheating and rolling. To give sheet steel a better finish it may be cold rolled. Cold working a steel increases its hardness and tensile strength but reduces its ductility.

Structural shapes are made by reheating blooms and passing them through a series of rolls. The first pass has approximately the shape of the bloom, see figure 43. Each succeeding pass approaches the final shape of the finished product. To produce a standard 10-inch I-beam from a bloom 8 by 10 inches, 10 passes are necessary as shown in figure 43. The long lengths are cut to specification, straightened, and finally inspected before shipment.

Drawing Wire

You have used a great deal of wire rope, and you will use

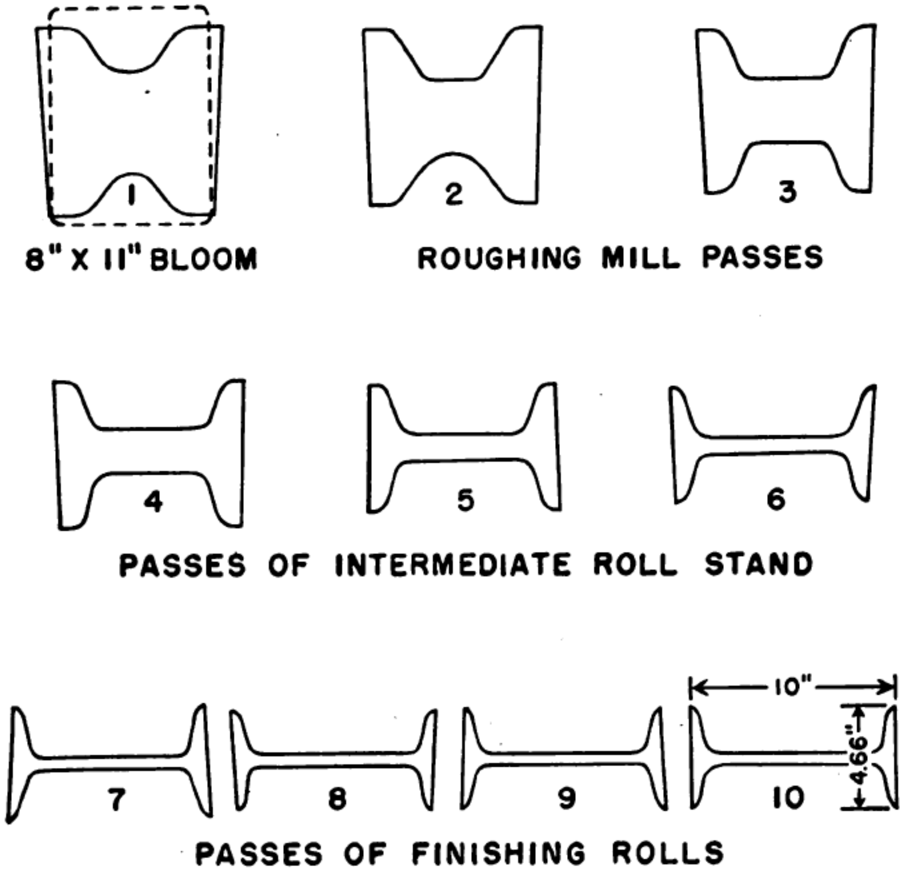


Figure 43.—Typical roll passes in forming a ten inch I-beam.

a great deal more during your career as a Steelworker. Wire for the manufacture of wire rope and other wire products is made by drawing wire rod at room temperature through tapered holes in wire drawing dies. The material from which wire is made is hot rolled steel rod having the desired chemical composition and grain structure. To draw wire, the end of the rod is pointed and pushed through the tapered hole in the die. Sufficient wire is pulled through the die so that it can be attached to a power operated drum (see fig. 44).

The drum is then rotated at a speed which will draw the wire through the die at the desired rate. Wire is drawn through successively smaller dies until the desired diameter is secured. As the wire passes through the dies, the steel is severely cold worked. Only a limited amount of cold working is possible before the wire becomes too brittle for further drawing. Almost any degree of hardness and strength can

be obtained in the finished wire by controlling the composition of the steel and the reduction in size.

Pipe and seamless tubing also may be made by drawing steel rod over a special mandrel. Another method for producing pipe and tubing is to form long strips of plate into cylinders and weld the edges.

Other steel products are produced by stamping and casting. Stamping is similar to forging except that the metal worked is in the form of sheets and it is worked cold. Cast steel products are produced by pouring molten steel into sand molds.

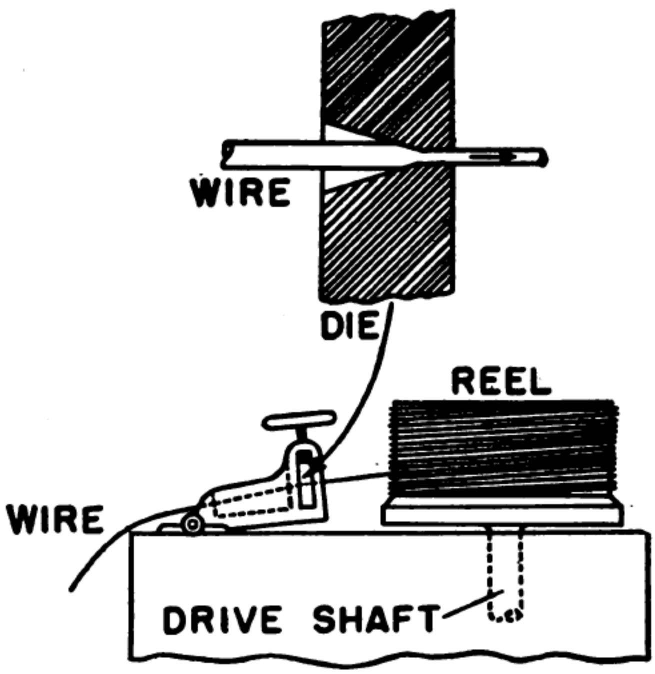


Figure 44.—Wire-drawing block and enlarged section of die.

PHYSICAL TESTING OF STEEL

The quality of steel is usually determined by its hardness and tensile strength. There are other physical properties of steel that also may be measured such as its strength under compression, shear strength, and impact strength.

The TENSILE STRENGTH of a steel is determined by pulling apart a carefully prepared sample. The testing is performed on a testing machine which enables the operator to determine the

number of pounds pull it takes to break the sample. This figure is converted to tensile strength in pounds per square inch. Tests to determine the tensile strength of steel also reveal the ductility of the metal.

Steel may possess two kinds of HARDNESS. One is resistance to abrasion, the other resistance to indentation. Tests for hardness of steel are usually based on the resistance of the material to indentation. There are three common methods for measuring the hardness of steel. They employ the Brinell testing machine, the Rockwell hardness tester and the Shore scleroscope. The first two machines measure hardness, based on the measurement of the indentation produced by a small steel ball under a given load. The Shore scleroscope measures the rebound of a small diamond-tipped hammer which is dropped from a fixed height. It is unlikely that you will use any of these testing machines but you may run across hardness numbers in literature and specifications. Table 3 may be of practical value to you in understanding the meaning of the various hardness numbers.

As a practical field test for hardness of steel you can use a good quality file. To file test a piece of steel move a sharp file slowly across it as you apply a steady downward pressure. If the material resists the cutting action of the file it is said to be FILE HARD. The upper limit in hardness of steel that can be filed is about Rockwell hardness C-60.

CLASSIFICATION OF STEEL

There are a number of ways of classifying steel. It may be classified according to method of manufacture or according to composition, use, methods of shaping, or microscopic structure. Let's look at a few of these classifications so that you will be better able to understand the terms used to describe steel of various types.

Each steel making process yields steel having special characteristics.

Table 3.—COMPARISON OF HARDNESS NUMBERS

Brinell hardness Nos.	Rockwell hardness Nos. "C" scale 150-kg. load and 120° cone	Rockwell hardness Nos. "B" scale 100-kg. load and $\frac{1}{16}$-in. ball	Shore scleroscope hardness Nos.	Approximate tensile strength in units of 1000 lbs. per sq. in.
653	62	...	86	329
627	60	...	84	317
601	58	...	81	305
578	56	...	78	295
555	55	...	75	284
534	53	...	73	273
514	51	...	71	263
495	50	...	68	253
477	48	...	66	242
461	47	...	64	233
444	46	...	62	221
429	44	...	60	211
415	43	...	58	202
401	42	...	56	193
388	41	...	54	185
375	39	...	52	178
363	38	...	51	171
352	37	...	49	165
341	36	...	48	159
331	35	...	46	154
321	34	...	45	148
311	32	...	43	143
302	31	...	42	139
293	30	...	41	135
285	29	...	40	131
277	28	...	38	127
269	27	...	37	124
262	26	...	36	121
255	26	...	35	117
248	24	100	34	115
241	23	99	33	112
235	22	99	32	109
229	21	98	32	107
223	20	97	31	105
217	18	96	30	103
212	17	95	30	100
207	16	95	39	98
197	14	93	28	95
187	12	91	27	91
179	10	89	25	87
170	8	87	24	84
163	6	85	23	81
156	4	83	23	78
149	2	81	22	76
143	..	79	21	74
137	..	77	20	71
131	..	75	19	68
126	..	73	18	65

Basic open-hearth steel is produced by the basic open-hearth process as previously described in this chapter. Over 90 percent of the steel produced in this country is produced by this method. Basic open-hearth steel is made into structural shapes, rails, bars, sheets and plates, for many purposes.

Acid open-hearth steel is made in much the same manner as basic open-hearth steel with the exception that the hearth is acid. Acid open-hearth is usually purer than basic open-hearth steel. For this reason it is preferred for some uses where a superior grade is necessary. Armor plate and special wire for wire rope are made of this kind of steel.

Bessemer steel is made as previously described. Most of the steel made by this process has a relatively high percentage of phosphorus and sulphur which makes it easier to machine than steels low in these elements. A large proportion of Bessemer steel is cold finished for industrial purposes such as bars for screw-machine products, strips for welded pipe, wire, sheets for tin plate, concrete reinforcing bars, and structural sections.

Electric furnace steel may be purified to any extent desired. Thus this process is used to produce high quality alloy steel for tools and other purposes.

Crucible steel has been largely replaced by electric furnace steel for the manufacture of tool steels. However, a small amount of tool steel is still made in crucibles.

Steel is also classified according to its composition. There are two broad classifications: carbon steels and alloy steels.

Carbon steels are also called simple carbon, plain carbon, straight carbon, and ordinary carbon steels. Carbon steels are steels in which carbon is the only element employed to control physical properties. They may contain some manganese (less than 1%) and a minimum of other impurities. Carbon steels are divided into three classes:

1. Low-carbon steels with carbon up to 0.30 percent.
2. Medium-carbon steels with carbon from 0.30 to 0.60 percent.
3. High-carbon steel with carbon above 0.60 percent.

Alloy steels have special physical or chemical properties which are dependent on the addition of metallic elements other than those present in carbon steels, or on an increase in either silicon or manganese. Nickel, chromium, molybdenum, vanadium, manganese, silicon and tungsten are the chief alloying elements. These elements may be used separately or in combination to produce the desired characteristics in the steel.

Alloy steels may be produced in structural sections, sheets, plates, and bars for use in the as-rolled condition. Better physical properties are obtained with these steels than are possible with hot rolled carbon steels. These alloys are employed for structures in which strength of material is especially important. Bridge members, railroad cars, dump bodies, dozer blades, and crane booms are commonly made from alloy steel.

Let's take a brief look at some of the alloy steels.

NICKEL STEELS usually contain 3 to 5 percent nickel which increases the strength of the steel, makes it tougher, and makes it better able to resist corrosion.

CHROMIUM STEELS resist wear. Ball bearings and similar products are made of an alloy containing about 1 percent chromium and 1 percent carbon.

CHROME-VANADIUM STEELS possess a maximum of strength with a minimum of weight. Take a look at a good set of 12-point box-end wrenches. You'll see "chrome-vanadium" stamped on the handles. Steels of this kind contain 0.15 to 0.25 percent vanadium, 0.60 to 1.50 percent chromium, and 0.10 to 0.60 percent carbon. They are used mainly where great strength is required as in gears, crank shafts, and axles.

TUNGSTEN STEEL possesses the unusual property of remaining hard at high temperatures. It will remain hard even at red-hot temperatures. This property of red hardness makes tungsten steel especially suited for high speed cutting tools.

MOLYBDENUM is often used as an alloying agent for steel in combination with chromium and nickel. The addition of molybdenum adds toughness to the steel.

There are many other alloy steels. In fact steel is tailor made to fit many different jobs.

GRAIN SIZE AND PHYSICAL PROPERTIES

Steel is composed of crystalline grains. You can see this grain structure by looking at the freshly fractured surface of a piece that has been broken. But to determine the grain size of a given piece of steel more elaborate equipment than a pair of eyes is required.

The grain size of steel definitely influences its physical properties. If two pieces of steel of the same chemical composition but different grain sizes were subjected to physical tests, the results would be as shown in table 4.

Table 4.—EFFECT OF GRAIN SIZE ON THE PROPERTIES OF STEELS

Property or condition	Coarse grained steel	Fine grained steel
Hardenability.............	Deeper.............	Shallower.
Machinability.............	Lower.............	Higher.
Ductility at same hardness..	Lower.............	Higher.

The grain structure of steel is altered by heat treatment and hot and cold working. Heat treating is beyond the scope of this book. However you will find a good discussion of this subject in *Metalsmith 3 & 2* (NavPers 10565-A).

When you bend or hammer a piece of steel to get it into place you are, in effect, cold working the metal. Steel that is cold worked has its grain size reduced (see fig. 45). Steel that has a smaller grain size is less ductile and harder than coarser grained steel. Thus with repeated cold working a piece of

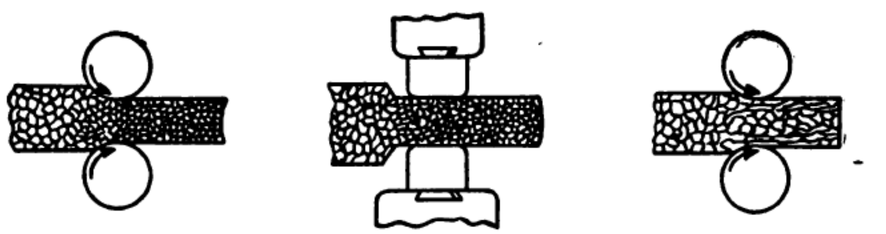


Figure 45.—Effect of working on grain size.

steel becomes brittle and will break. This is commonly called crystallizing. A wire rope that makes a sharp bend over a small sheave will break after continued use, not from wear as in ordinary use but because of crystallization.

BOOKS ON THE METALLURGY OF STEEL

The study of iron and steel is known as ferrous metallurgy. In this chapter, this subject has been covered briefly and generally. Since so much of your time will be spent working with steel you may desire to go more deeply into the study of ferrous metallurgy. It is a fascinating and interesting subject and there is a great deal of material available. Listed below are a few of the numerous books on iron and steel which you may want to read.

Metals Handbook, American Society for Metals, 1948. Cleveland, Ohio.

Tool Steel Simplified, Frank R. Palmer, 1937. The Carpenter Steel Co., Reading, Pa.

Principles of Heat Treatment, M. A. Grossman, 1935. American Society for Metals, Cleveland, Ohio.

The Elements of Ferrous Metallurgy, Joseph L. Rosenholtz, 1930. John Wiley & Sons, Inc., New York, N. Y.

An Introduction to the Metallurgy of Iron and Steel, M. H. Boylston, 1928. John Wiley & Sons, Inc., New York, N. Y.

The Making, Shaping, and Treating of Steel, J. M. Camp and C. B. Francis, 1925. Carnegie Steel Co., Pittsburgh, Pa.

BENDING REINFORCING STEEL

The cold bending of reinforcing steel bars is of paramount importance in view of the part which steel plays as a reinforcement for concrete. Properties which make steel a desirable reinforcement for concrete include high tensile strength and ductility. As a further advantage, the rate of contraction and expansion from temperature changes is about the same in concrete as in steel. This factor is essential to proper adhesion between the concrete and steel. Known as the bond of the steel,

adhesion allows the concrete and steel to work together as a unit under a load. The strength of the adhesion is termed the bond strength.

As a Steelworker 1 or Chief Steelworker it will be to your advantage to know some of the theory applicable to cold bending. A knowledge of this will be an asset and may prove very helpful to you in meeting problems that will arise in your work. Now let's see what goes on within the metal bar being subjected to bending.

In the process of bending, a big change takes place within the rod. There's a flow of metal inside the material, which results in a change in the dimensions of the part formed. The fact that the flow of metal occurs at a stress in the "plastic range" of the material means that the material will maintain its changed form after the forming stress is no longer applied.

At this point we might explain that, by the application of force upon a ductile material such as steel, you can cause the material to increase (as well as decrease) in length. You may have heard that the change in length (longer or shorter) will occur at a constant rate if the forming force is increased at a constant rate. This is true, all right—but only to a certain point. What happens is that if you continue to increase the force, a level is reached at which the deformation rate will commence to increase rapidly. This takes place at a definite loading point. Additional increase in the forming force will speed up the deformation rate and soon cause the material to break.

To better understand the theory of cold bending, make sure you familiarize yourself with the meaning of these words: stress, yield stress, ultimate strength, elastic limit, and plastic range.

STRESS is the amount of internal force which resists a change in the form of a body or mass.

YIELD STRESS is the stress at which the rate of stretching begins to increase markedly.

ULTIMATE STRENGTH means the stress at which the material will break.

ELASTIC LIMIT is the greatest stress which a material is capable of withstanding without taking a permanent set or deformation.

PLASTIC RANGE indicates the stresses ranging between the yield stress and the ultimate strength. It is in this range that a flow of metal occurs inside the material and makes possible a permanent change in the dimensions of the material; thus the material will retain its changed form after the forming stress is no longer applied.

Bar Sizes

The sizes of reinforcing bars are presently referred to by bar numbers, which are based on the number of eighths of an inch in the nominal diameter of the bar. As you may know, bars formerly were designated by type and size, like a 1-inch square or a ¾-inch round bar. (Square types of bars are also obsolete.) Current types include plain round and round deformed bars.

The obsolete bar designations and the present designations are given in table 5 below:

Table of typical equivalents

[This table is for informational purposes and is not part of the simplified practice recommendation]

Obsolete bar designation (size, in.)	Current bar designation	Unit weight per foot	Nominal dimensions—round sections		
			Diameter	Cross-sectional area	Perimeter
Rounds:	*No.*	*lb.*	*in.*	*sq. in.*	*in.*
¼	[1] 2	0.167	0.250	0.05	0.786
⅜	3	.376	.375	.11	1.178
½	4	.668	.500	.20	1.571
⅝	5	1.043	.625	.31	1.963
¾	6	1.502	.750	.44	2.356
⅞	7	2.044	.875	.60	2.749
1	8	2.670	1.000	.79	3.142
Squares:					
1	[2] 9	3.400	1.128	1.00	3.544
1⅛	[2] 10	4.303	1.270	1.27	3.990
1¼	[2] 11	5.313	1.410	1.56	4.430

[1] Bar No. 2 in plain rounds only.

[2] Bars Nos. 9, 10, and 11 correspond to the former 1-in. square, 1⅛-in. square, and 1¼-in. square sizes, and are equivalent to those former standard bar sizes in weight and nominal cross-sectional area.

Table 5.—Table of typical equivalents.

To produce the desired change (or bend) in the material during the plastic flow of the metal, it is important that the bending operation be done cautiously and properly. Thus, you can see the advantage of power machines for bending. If the hand method of bending is used, avoid hurrying while the actual bending operation is under way. Besides applying a slow, even pull on the rod, keep the curve of the bend round enough to resist cracking or breaking.

To make a bend by hand in a heavy reinforcing rod, start by making an outline of the shape the bar is to have, on your bending table. Then bore holes in the bending table at the points where the bend will be made. Next insert steel bars or steel plugs about 6 inches long in these holes; then nail boards to the table as indicated in figure 46, so that the rod will remain in place during the bending operation.

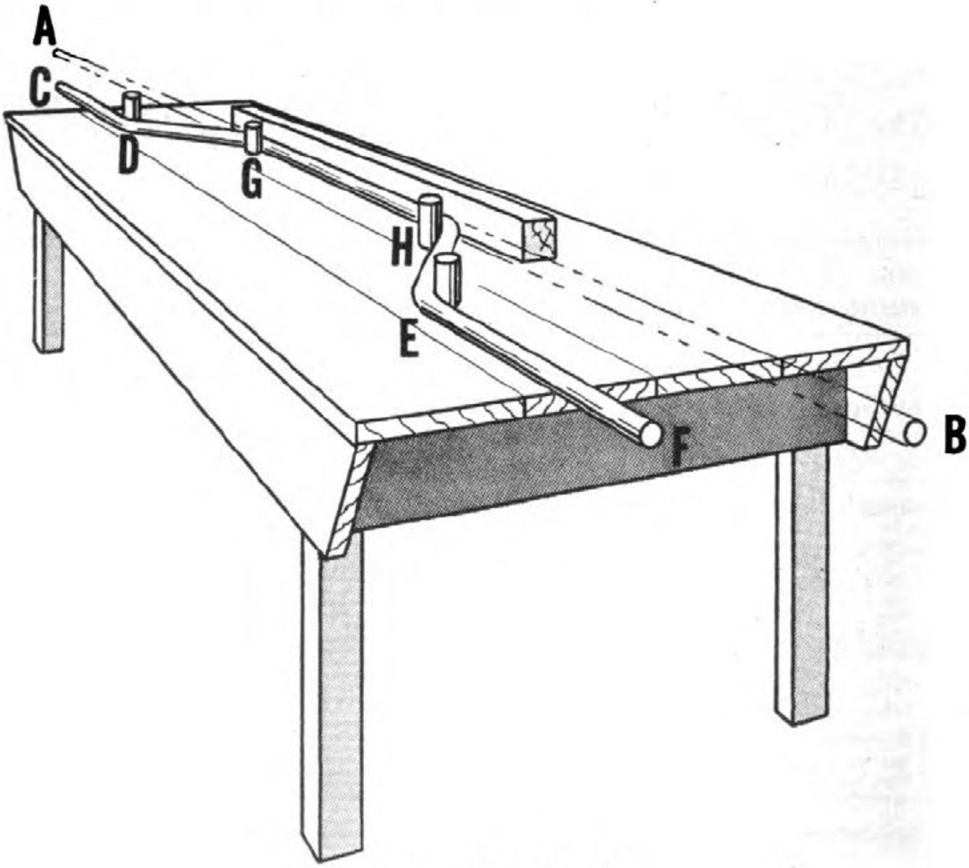


Figure 46.—Hand bending.

Now to get down to the bending, using as an example the operation given in figure 46: lay the rod as indicated by line *AB*, bend it around the plugs labeled *G* and *H*, then around the two lower plugs *D* and *E*, and finally, get parts *C* and *F* in line with *A* and *B*.

When a bending machine is not available, the problem of bending beam and girder bars is not as difficult as it might sound. Locate a piece of heavy pipe which can be slipped on the bar and then proceed to make the bends needed, employing either steel plugs or angles bolted to the table.

A vise, secured to a table, provides a method of hand bending when the job calls for bends having a short radius. Simply insert the bar in the vise at about the spot of the intended bend. Then pull on the end of the bar until you obtain the proper angle.

Machine Bending

A power-driven bending machine is a big timesaver where you have a large number of bends to be made. There are various types and makes of power-driven benders available. Make sure that the men you assign to operate bending machines for the first time are properly instructed beforehand.

Your shop may have a hydraulic full automatic reinforcement bar bender like that shown in figure 47. The labels in the illustration will help you to understand the name and location of various parts of the machine. Standard bending pins with bending forms are provided in the following sizes: 2½″, 3″, 3½″, 4″, 4½″, 5″, 5½″, 6″, 7″, 7½″, and 8″, 10″, and 12″ diameter.

A major advantage of this machine is that, with rods ranging from ⅜″ through 1″ in size, it can bend more than one rod at the same time. (See fig. 48.) It can also make two offset bends in a 1¼″ rod in one operation. The capacity of the machine to bend more than one rod at a time, according to the size of rod, is as follows:

Bar Size	*Capacity*
⅜″	10
½″	8
⅝″	6
¾″ (or ⅞″)	3
1″	2

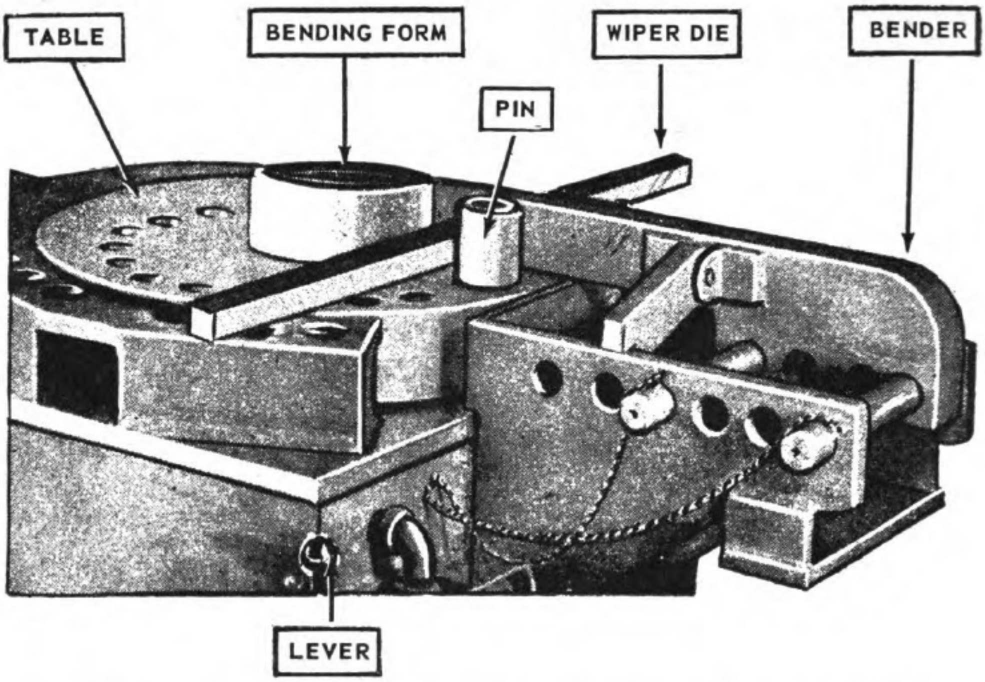


Figure 47.—Wallace No. 47 hydraulic reinforcement bar bending machine.

In making a bend, first insert the proper bending pin and bending form in the table of the machine. Then place your rod in the bender, positioning it as shown in figure 48.

The machine is started merely by pulling the hydraulic hand lever. When this is done, the center portion of the table, as well as the wiper die and bender arm, rotates, and the rod is bent to the desired shape. The hand lever is moved to the right for a right-hand bend and to the left for a left-hand bend.

You can also make duplicate bends on the machine shown in figure 47. For this purpose, control stops are mounted on an external control drum. One of these stops will allow you to set the machine so that it will always stop automatically at the same point. Another of these control stops will also cause the lever to lock automatically into bending position and to disengage automatically, either right hand or left hand.

After the desired bend is made, shifting the lever in the opposite direction will cause it to lock in place and cut out automatically at the starting point. The stopping action is fast, as well as accurate.

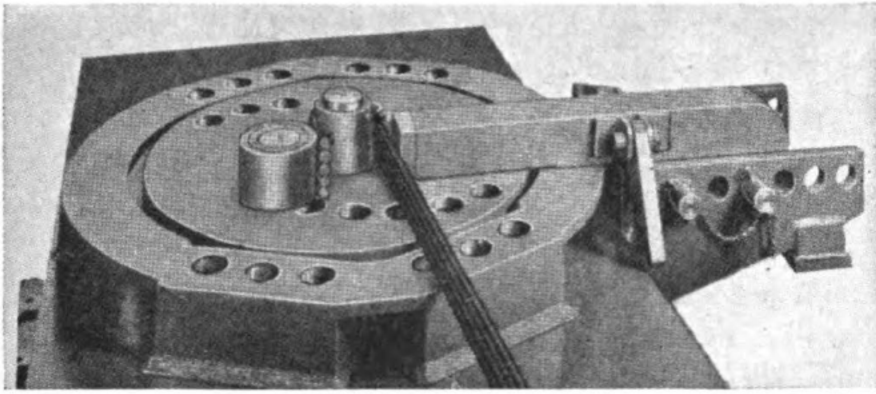


Figure 48.—Bending five hooks in one operation.

Shop Arrangement

As a Steelworker 1 or C you should be able, if called upon, to set up and operate a reinforcing steel bending shop. That may sound like a big order, but with a little briefing you should not find this task as difficult as it sounds.

Two of the major considerations in setting up a reinforcing steel bending shop are efficiency in handling work and safety of personnel and equipment.

Quite often you may find that space is strictly limited, in which case "don't spare an inch" in utilizing to best advantage the amount of space available.

The position of machines should allow sufficient working space and not create any hazard or interference from traffic in the aisles or work lanes. Also, allow sufficient clearance between adjacent machines so that men working on them at the same time will not be in the way of each other or otherwise endangered.

Make provision for an adequate number of benches or tables on which to bend bars by hand. If necessary to make your own tables, follow the fabrication procedure given in *Steelworker 3 & 2* (chapter 8). Make sure these benches are of substantial build and that they are secured against tipping. Place them on a level surface.

You will need adequate storage space for stock. See that incoming stocks of reinforcing bars are stored according to size, and that they are near enough at hand that your men won't

have to be running back and forth to get bars from a distant stock pile. In other words, make materials as accessible to the place where they will be used as available space will permit. You may find it practicable to use racks for storing bars that have been bent. When this is done, designate and label each rack according to the size of rod to be stored on it.

You'll need an office or desk space, but keep it as small as practicable, especially when space is at a premium. An ideal location for the office is near the shop entrance because the result will be less traffic near workmen and machines.

Operating Procedure

A standing operating procedure is needed if you expect to turn out a high quality of work and complete the jobs assigned to your shop on time. See that the procedure you follow is based on the most practical and economical way of doing the job. Encourage your men to express their ideas on how to do a job, but require that they first demonstrate a proposed new method for your evaluation and approval before adopting it as standing operating procedure. Also, when equipment or regulations change, make sure your men are informed and that they understand how the change will affect them in their work.

To help you maintain a smooth flow of production, give careful attention to incoming work requests and the promptness with which they are filled. As for work requests having a "rush" priority, make every effort—as a good supervisor—to cooperate fully in expediting each of them. To estimate the time required to complete a job and to plan your work in advance, know the amount of work that each man in your shop is capable of producing. In arriving at this estimate, take into consideration such factors as the facilities of your shop, the type of work to be done, the qualifications of the men who will do the work, and the like. Suppose, for example, that you have a work request which calls for 100 eighth or quarter bends in bars ½" in diameter. Taking into consideration the various factors pertinent to the job, you may wind up with an estimate like 3 to 4 hours by hand, and 1 to 1½ hours by machine.

The number of hours required to bend 100 bars ½″ in diameter may be much less than that needed to bend the same number of bars 1″ in diameter. Therefore, make a study of the production situation in your shop and prepare an estimate of the hours needed to bend various size rods, both by hand and machine.

Remember to keep materials handling to a minimum and insist that your men observe safe handling practices. See that your men handling reinforcing steel wear leather gloves.

There will be some paper work—like keeping job completion and progress reports prescribed by your particular activity. See that each record is maintained properly and kept up to date. In that way you will have a better picture of the internal operations of your shop and of the efficiency being achieved.

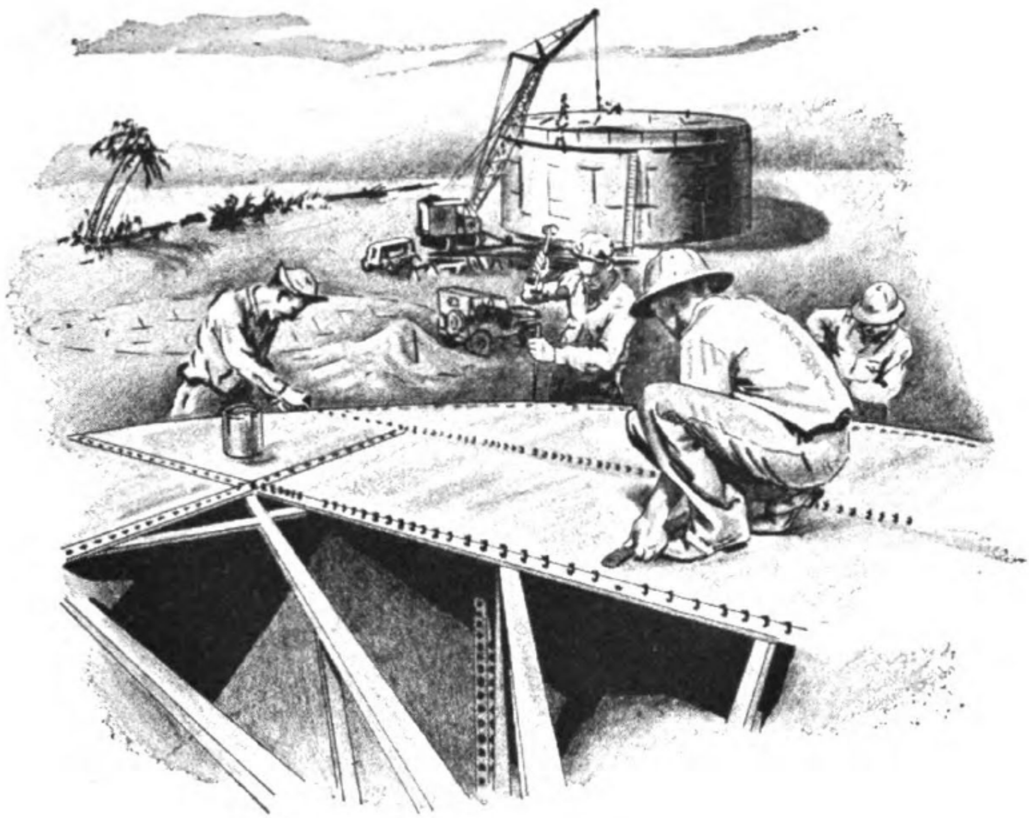
Don't overlook good housekeeping as one of the important functions of a well-run shop. Keep trash, pop bottles, and other such matter off the floors. Also, see that equipment receives the care and maintenance needed to keep it in good operating condition. A neat, orderly shop not only aids efficiency, morale, and output, but also contributes toward a low accident rate.

Supervision and training should also play an important role in shop operation. These topics are covered separately in chapters 7 and 8.

QUIZ

1. What are the raw materials used in the manufacture of pig iron?
2. Steel is an alloy of iron and other elements. What element has the greatest influence on the mechanical properties of steel?
3. How does manganese affect the physical properties of carbon steel?
4. How does silicon affect the physical properties of carbon steel?
5. Name three modern processes for making steel.

6. What method of manufacture is used to produce most of the steel used in this country?
7. Briefly explain the Bessemer process for purifying pig iron.
8. Give two reasons for working ingot steel.
9. What is the most important method of shaping steel?
10. How is wire manufactured?
11. What percentages of carbon does medium carbon steel have?
12. What property does a molybdenum steel have?
13. What is stress?
14. How can a pipe be used to bend girder bars by hand?
15. How is the hand lever on the power bender, illustrated in this chapter, used to make a right-hand and left-hand bend?
16. What are two major considerations in setting up a reinforcing steel bending shop?
17. How would you label racks to be used for storing bars that have been bent?
18. What part should leather gloves play in the operation of a reinforcing steel bending shop?



CHAPTER 5

STEEL FABRICATION

BUILD IT YOURSELF

You belong to an outfit that is noted for its ingenuity. During the last war, if supply didn't have it, the Seabees made it.

Your steel work won't be confined to the erection of prefabricated structures such as towers, tanks, and Butler buildings. There will be times when the job you are assigned will require you to start from scratch.

Your ability as a Steelworker will be reflected in the manner in which you and your men turn out these special jobs.

THE JOB PLAN

The beginning of the job is the job plan. First, you have to understand what the job is, what it will look like when it's finished, and its function. This information should

appear on the job order. If it doesn't, get in touch with the originator of the job order and get the details.

Now after you know definitely what the job is, determine how you can do it and determine the men, material, and tools required. For example, suppose you are in charge of erecting a tank. Suppose further that the manhole cover has been lost in shipment. You'll make one. But what gage steel will you need? How will the steel be cut? What size are the bolt holes? How will you make them? How will you line them up with the holes in the tank? Who will you put on the job? Will he need help?

After you have considered these questions carefully and arrived at satisfactory answers, you are ready to begin the job. On another job you might have different conditions, so it is necessary to analyze each job. Take every factor into consideration. Don't let your men go on the job "half cocked". Study the problem from every angle. Visualize the effect that various production methods and materials will have on the final product. Weigh the advantages of each, and select the method and materials that will best serve the purpose.

Estimate the quantity of time and material required to do the job, and be sure that needed materials are available. Foresee the need for special tools and handling equipment. Have everything ready for the job before it is begun.

Care should be exercised in the assignment of jobs. Rotate the type of work so that the most difficult jobs don't fall on the shoulders of the same man each time. Assign strikers or rated men who are weak in the skills required for that particular job to assist with the work so they will gain experience in all the skills required of a Steelworker.

If speed is a factor, assign your best men. But if plenty of time is available, give those men who need experience a chance to get in some practice.

You should analyze each job as soon as you receive the work request. Then you should pass the ideas you form about it along to the men you assign to do the work. If it is a job that is difficult to explain or if the men doing the job have trouble visualizing the job, make sketches and drawings so

that the work required is perfectly clear.

Even a striker often has some very good ideas. Invite, consider and utilize the worth-while suggestions made by your men. Encourage them to use initiative and work out details for themselves. But always be ready to give them the benefit of your experience.

GETTING THE JOB DONE

After you have assembled the material and tools, get the work underway. Give your men all the help and advice they need, but use discretion and common sense in your supervision.

Keep up with the job. Know what progress is being made and iron out difficulties as they occur. Adequate inspection will keep you "in the know". When the work has been completed to your satisfaction, have the job inspected and accepted by the activity or individual that requested the work.

Jobs must be completed to the satisfaction of the requesting authority. When a job is not satisfactory the necessary changes must be made. Proper planning, and supervision, will avoid waste of material and save valuable time.

SPECIAL JOBS

You and your men will build and repair all types of steel products such as crane booms, tank staves, dozer blades, frames, and parts for all types of heavy equipment.

You may be given a complete set of prints with the job; a broken part to repair or duplicate; a rough drawing; or nothing more than a brief work order or oral request.

LAYOUT TOOLS

Most of the jobs you are given will require a certain amount of layout work.

The tools you will use most often in laying out jobs are: the scratch awl, soapstone, straightedge, dividers, rule, steel tape, compass, punch, steel level, trammel points, and hammer. Some of these tools are shown in figure 49.

Layout work is essentially a process of measuring and

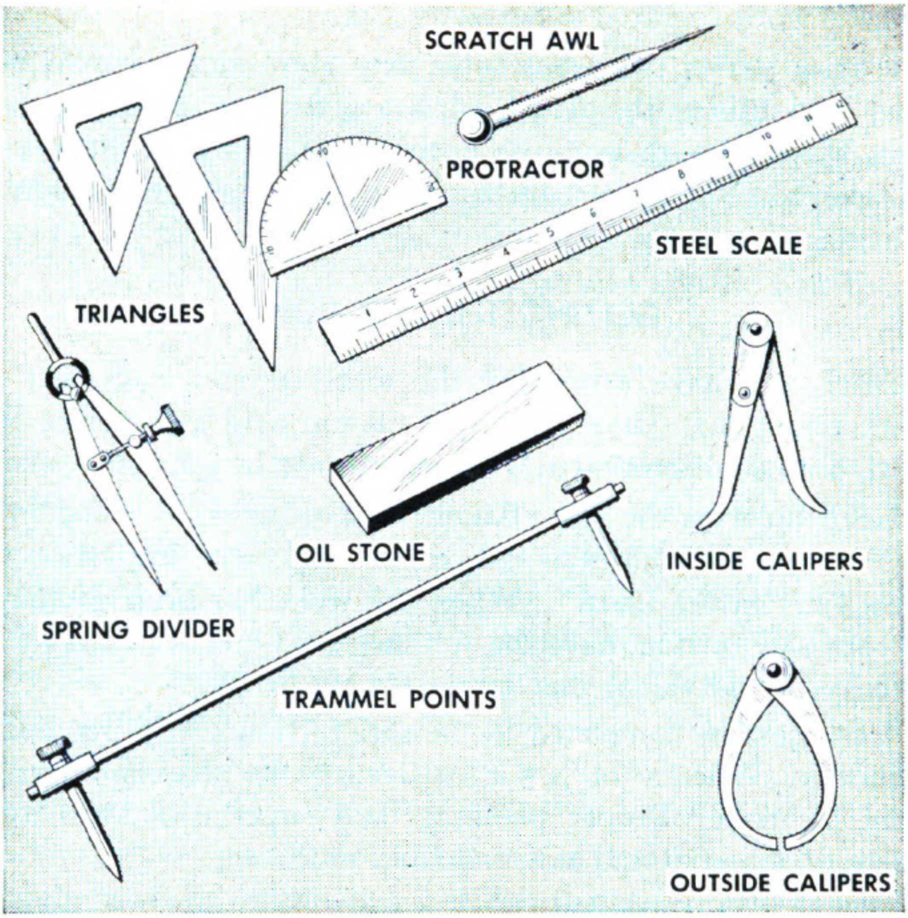


Figure 49.—Layout tools.

marking. After you have made a few practice layouts, the importance of accurate measurements will be firmly impressed on your mind. You will have a feeling of satisfaction when your layout "comes out" in the manner you planned. If it doesn't quite fit, the probability is that you were careless somewhere along the way.

USING LAYOUT TOOLS

Scratch awls, punches, and soapstone will be your marking tools. For most work you will use soapstone to do your marking. However, where dimensions have to be held very close you will use a scriber to mark your lines. To scribe a line with a scriber set the point of the scriber as close to the edge of the scale as possible by tilting the tool outward. Exert pressure

on the point and draw the line, tilting the tool slightly in the direction of the movement. For short lines, use a steel scale as the guide. For longer lines use a straightedge. When you have a line to draw between two points, punch each point. Start from one punch mark and scribe toward the center. Complete the line by scribing from the other punch mark in the opposite direction.

The flat steel square is a useful tool for laying out plate. In laying out certain work you may use a method known as parallel line development. In parallel line development you use the square to construct lines that are parallel to each other as well as perpendicular to the base line. This procedure is illustrated in figure 50.

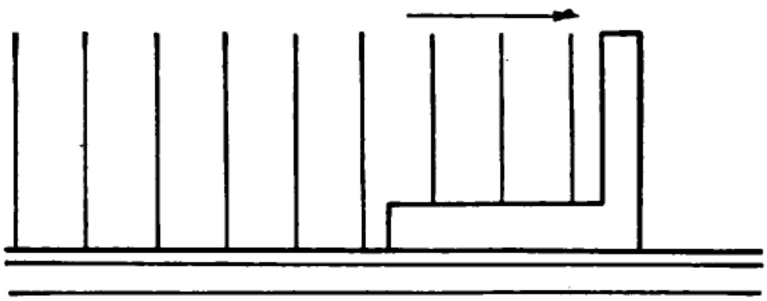


Figure 50.—Drawing perpendicular parallel lines.

Just clamp the straightedge firmly to the base line. Slide the body of the square along the straightedge, and draw perpendicular lines through the desired points.

The combination square can be used to draw a similar set of lines as illustrated in figure 51. The edge of the plate upon which you are working must be square when you use this method since it acts as the straightedge. As you can see in figure 51 one edge of the combination square is 90° and the other edge is 45°.

While most tools used in steel working are pretty rugged and can be dropped and tossed around without undue damage, layout tools must be handled with care. This is especially true of the combination square. The combination square is a delicate instrument and will be of little value to you if it is given rough treatment. Stow your tools properly when you are through

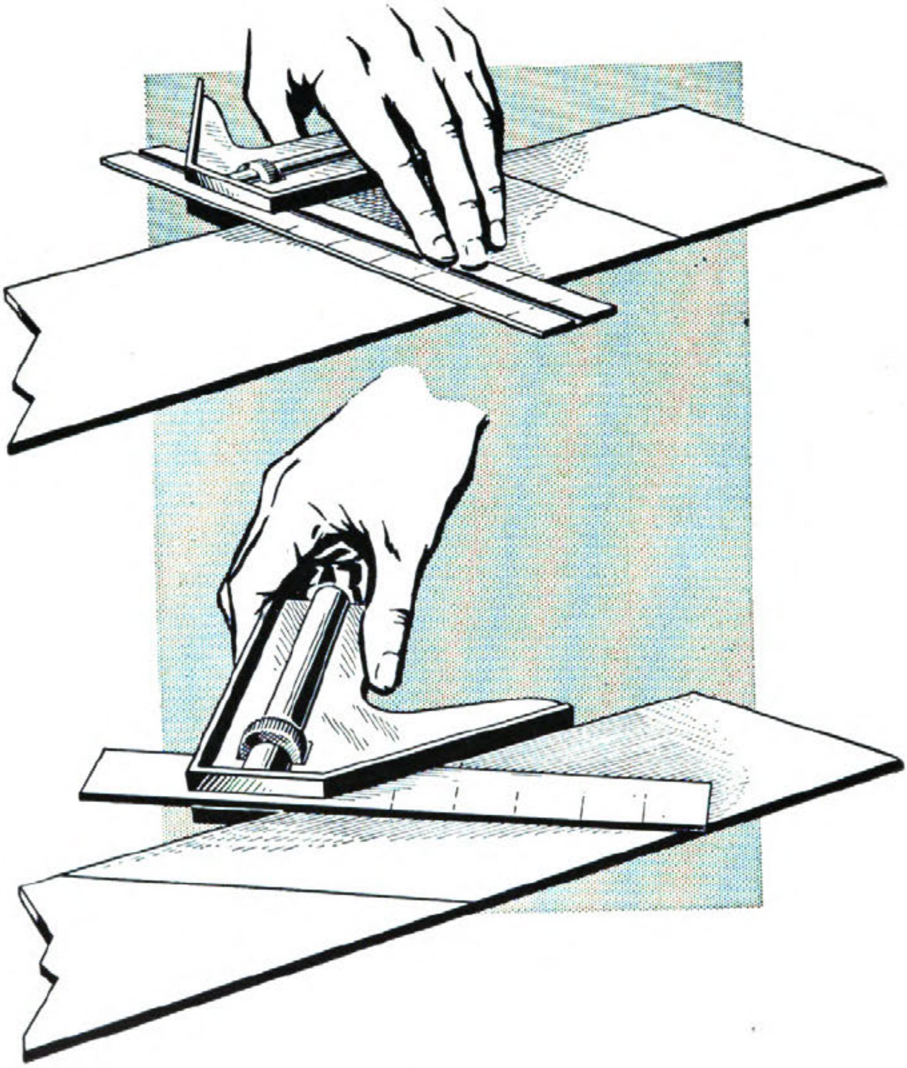


Figure 51.—Using combination square.

using them. Keep them clean and in tiptop shape and you'll be able to get accurate layouts.

For constructing angles other than 90° or 45°, you will use a protractor. To lay out an angle with the protractor, first mark the vertex of the angle on the base line with a prick punch. Set the vertex of your protractor on this mark (see fig. 52) and scribe a V at the desired angle (in this case 70°). Now place a straightedge between the two points and scribe or draw in the line to form your angle. Since the protractor is a half circle, it contains 180°, so when you construct an angle

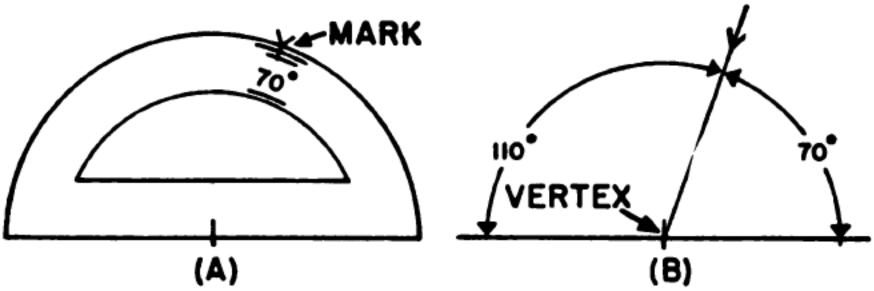


Figure 52.—Constructing an angle with a protractor.

of 70° to the right of the vertex the remaining angle to the left of the vertex is 110°.

When you are working on a layout that has to be very accurate you should mark your points lightly with a prick punch. Use light taps with a small hammer. The smaller the mark you make (so long as you can see it), the more useful and accurate that mark becomes.

You will use dividers to scribe arcs and circles and also to transfer measurements. Careful setting of the dividers is most important. When you transfer a measurement from a scale to the work, set one point of the dividers on the mark

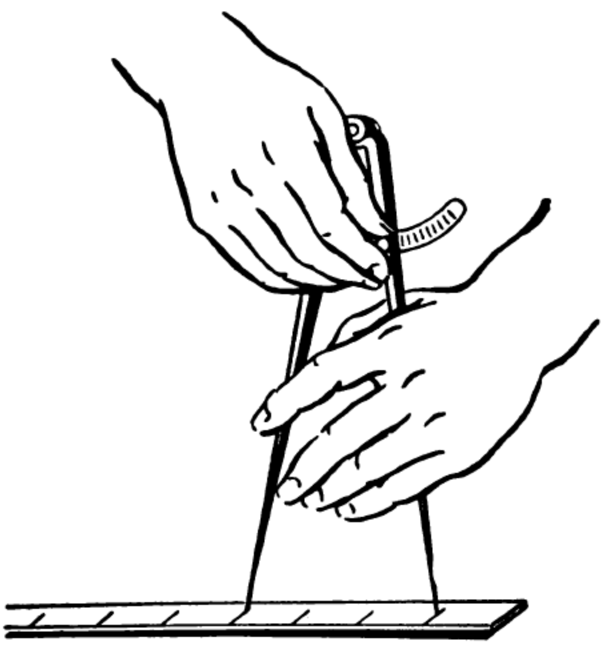


Figure 53.—Setting the dividers.

and accurately adjust the other leg to the desired length as illustrated in figure 53.

To scribe a circle, or an arc, grasp the dividers between the fingers and thumb, place the point of one leg of the dividers on the center and swing the arc. Exert enough pressure to hold the point on the center, slightly tilting the dividers in the direction in which they are rotated.

Trammel points serve the same function as dividers except that they may be extended to greater lengths than the points of the dividers. Thus you use trammel points for transferring longer measurements and drawing circles and arcs with longer radii than those that can conveniently be drawn with dividers.

Much of the marking you do will be done with soapstone. You can draw fairly accurate circles using string with a piece of soapstone tied to one end, if no dividers or trammel points are available.

LAYOUT WORK

The layout work you will do requires that you be thoroughly familiar with blueprints. Review the chapter on this subject in *Steelworker 3 & 2*. The basic training course, *Blueprint Reading,* NavPers 10077, will also be of value to you in your review of blueprint reading.

Before the first cut can be made on any piece of metal you or your men are going to make into a finished product, guide lines have to be provided. Layout work provides these guide lines. Thus layout work may be very simple or quite complicated, depending upon what is being made. When you measure off a 10-foot section of pipe and mark it, you are in effect making a layout.

To start a layout on plate work, you must first have a base line to work from. If the edge of the plate is true you may use it as the base line. Once you have established this line your measurements will start from there. Most of the prints you will use have center line references for dimensions so you should also mark center lines on your layout.

Figure 54 shows an envelope layout for a shallow tank to

be constructed of light plate. This method of layout for square and rectangular tanks locates seams in the flat sides instead of in corners. These seams are easier to weld and grind smooth. In the layout in figure 54, the notches are cut at an angle of 45°.

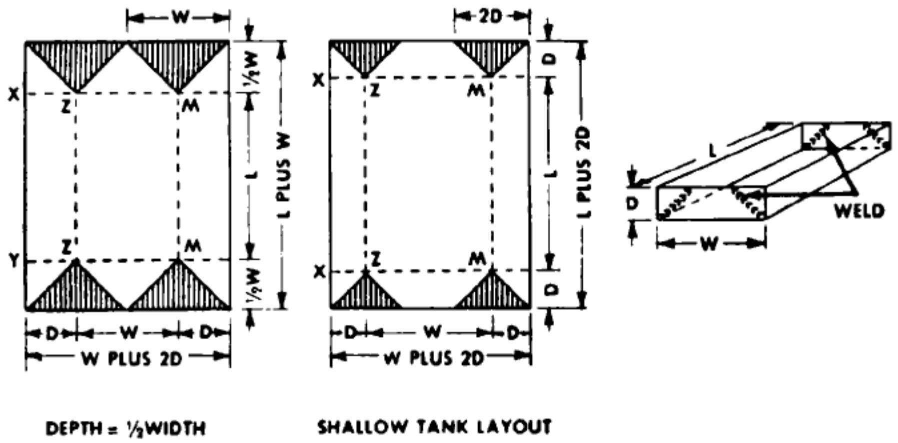


Figure 54.—Shallow tank layout.

The important thing to remember when making a layout is that the layout will be a full-sized reproduction of the blueprint or sketch you are working from. Care must be exercised in measuring dimensions and angles. Centers for holes must be accurately measured and marked. A sloppy inaccurate layout will result in wasted material and time.

BEND ALLOWANCE

Low carbon stock up to ¼ inch can be bent cold. When metal is bent at right angles, allowance should be made to compensate for shrinkage of the piece of metal. This allowance is equal to one-half of the thickness of the metal being bent. Thus if you are bending a piece of metal ¼-inch thick you should allow ⅛ inch extra length for the bend. When you are bending the metal in a vise, the allowance for the bend should be added to the part that extends above the vise jaws (see fig. 55).

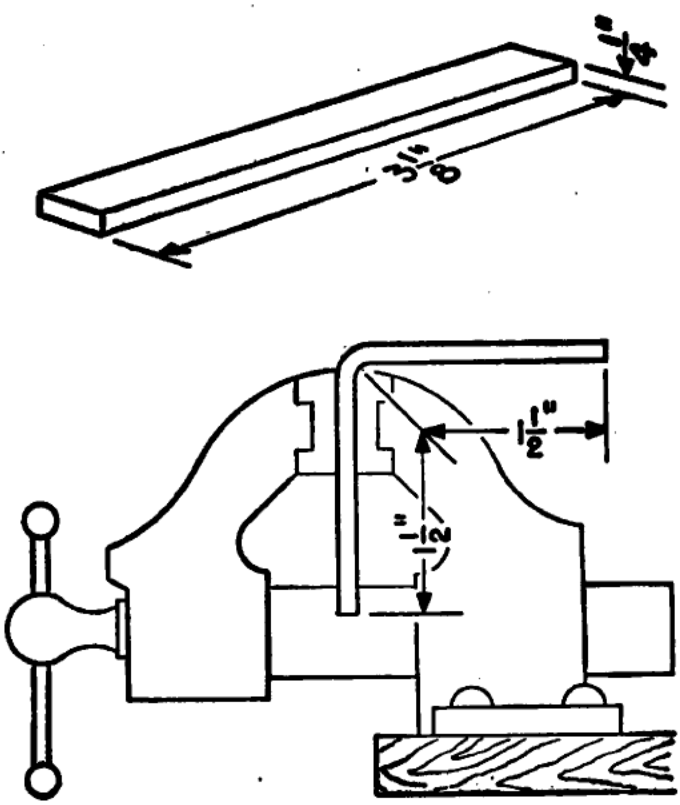


Figure 55.—Layout for a single bend.

The section that is clamped in the vise remains the same length while the part being bent loses in length. If you are making more than one bend in the same piece of metal, the order of bending must be determined before the proper bend allowance can be laid out.

PATTERNS FOR PIPE WORK

Not all of the layout work you will do will be on plate and flat sections. There will be times when you will be called on to weld pipe for water and fuel supply. To cut the pipe to the correct shape before it can be fitted and welded into the finished assembly, you will have to have a pattern or template for marking the pipe. To make patterns for this type of work you will use parallel-line development. Parallel-line development is based upon the fact that a line which is parallel to another line is, by definition, always an equal distance from that line at all points. The main lines of structures to be laid

out by parallel-line development are parallel to each other. Objects which have opposite sides parallel to each other, and which have the same cross-sectional shape throughout their length, are developed by this method. This includes such shapes as cylinders, prisms and their many variations.

In making parallel-line developments, you must observe certain fixed principles as follows:

1. A plan and elevation of the desired shape must first be drawn in which the parallel lines of the solid are shown in their true lengths. In other words, draw a plan and elevation view of the part's actual size.
2. Visualize the pattern from a right view of the article in which the miter lines or lines of intersection are shown.
3. Draw a line at right angles to the parallel lines of the solid. Each space contained in the section or plan view is placed on this line.
4. Draw the measuring lines at right angles to the line in "3" mentioned above.
5. Draw lines from points of intersection of the miter line, in the right view, intersecting similarly numbered measuring lines drawn from the stretch-out, to show outline of the development.
6. Trace a line through the points thus obtained to give the desired pattern.

Perhaps the principles in the preceding paragraph don't mean too much to you right now. Refer to them while you are reading the step-by-step discussion of the layout for a pipe intersecting a straight-sided tank at an angle as shown in figure 56.

To begin your layout first construct an elevation on the miter line similar to the one shown in figure 57. The miter line is the inclined plane created when the pipe meets the plate of the tank at an angle. The elevation is a front view. Line AB represents the diameter of the pipe. The distance between AB and the miter line may be taken as any convenient length, since of course, you won't show the full length of the pipe.

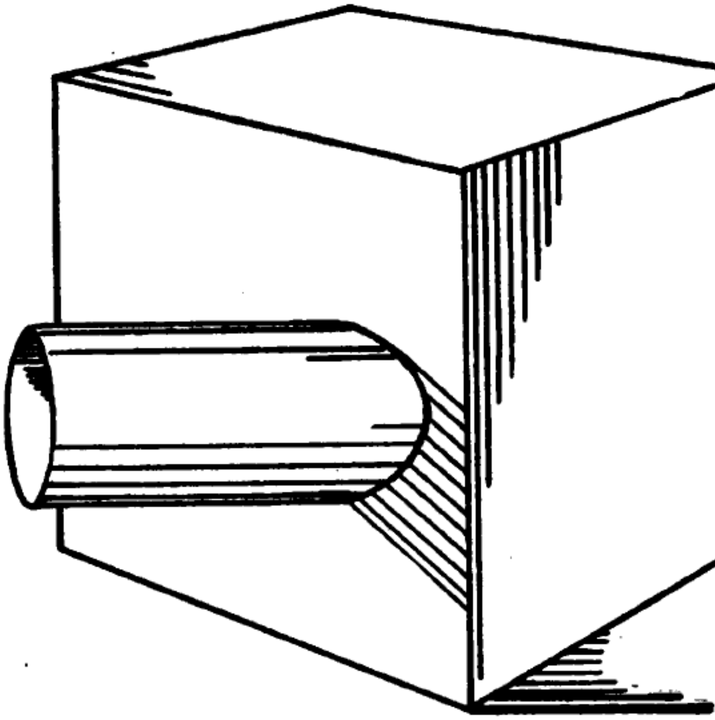


Figure 56.—Pictorial view of pipe intersecting a tank at an angle.

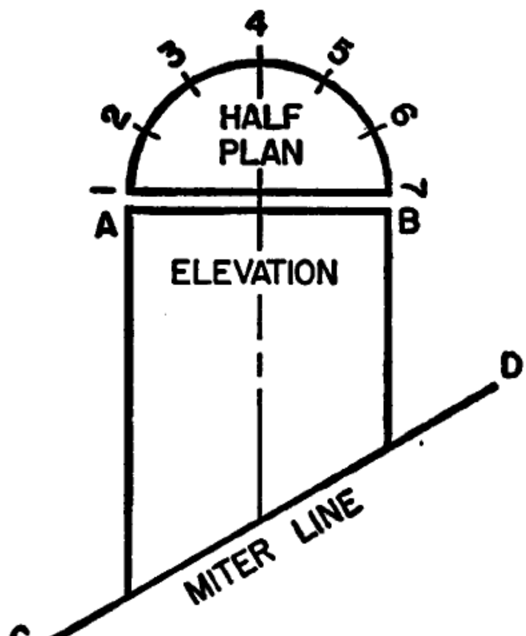


Figure 57.—Elevation and plan of intersecting pipe.

Now, determine the center of line AB, and construct a center line as shown in figure 57. Set your dividers for one-half the distance of line AB. Develop your plan by the following steps:

1. Construct line 1-7 parallel to and just above AB. Using the point at which the center line of the elevation intersects line 1-7, swing an arc with your dividers and complete the half plan as shown.
2. Step off the circumference of the half plan into six equal parts.
3. Now draw lines parallel to the center line from points 1, 2, 3, 4, 5, 6, 7 on the circumference of the half plan to the miter line (see fig. 58).
4. Draw line EF (an extension of line AB), and step off spaces 1 to 7 and 7 to 1, equal to the division on the half plan.
5. Draw line GH parallel to EF at a distance equal to the greatest height of the elevation.
6. Through the points 1–7–1 draw parallel lines as shown in figure 58.
7. At this point in the parallel line development, you are ready to transfer the miter line to the grid of parallel lines (called the stretch-out) and thus form your pattern. To do this you may use either of two methods:

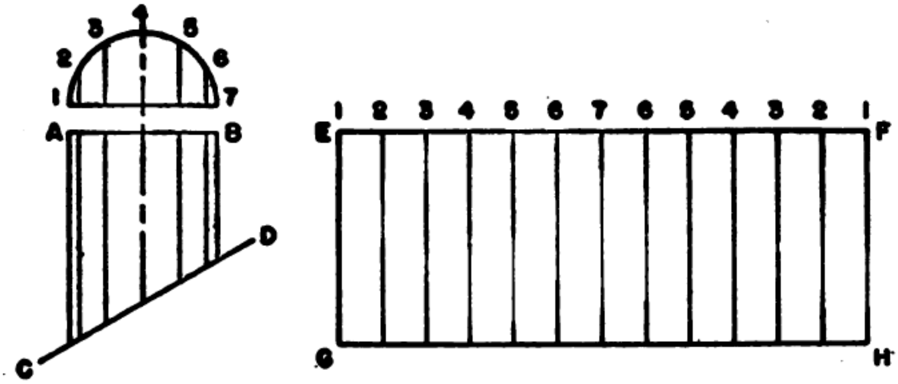


Figure 58.—Development of layout for intersecting pipe.

(1) By measuring and transferring that measurement from the elevation to the stretch-out, making use of your dividers.

(2) By protecting the points in the elevation to the stretch-out by parallel projection lines (broken lines).

No matter which method you use, you should come out with the same pattern if you make your measurements with care.

To develop your pattern by the use of dividers, follow these step-by-step instructions. As you read refer to figure 59.

1. Set the dividers along line 1, on the elevation, equal to the distance from line AB to CD.
2. Keep your dividers at this distance and transfer this measurement to the two lines numbered 1 in the stretch-out.
3. Then measure lines 2 in the elevation and transfer this measurement to the lines numbered 2 in the stretch-out. Repeat this procedure for lines 3, 4, 5, and 6.
4. Notice that there is but one line 7 in the stretch-out so you will only transfer this measurement one time.
5. Finally connect the points just measured on lines 1–7–1 on the stretch-out with a smooth curve as shown in figure 59.

To obtain the pattern by projection, you merely project parallel broken lines from the points of intersection on the miter to like-numbered lines in the stretch-out, as shown in figure 59.

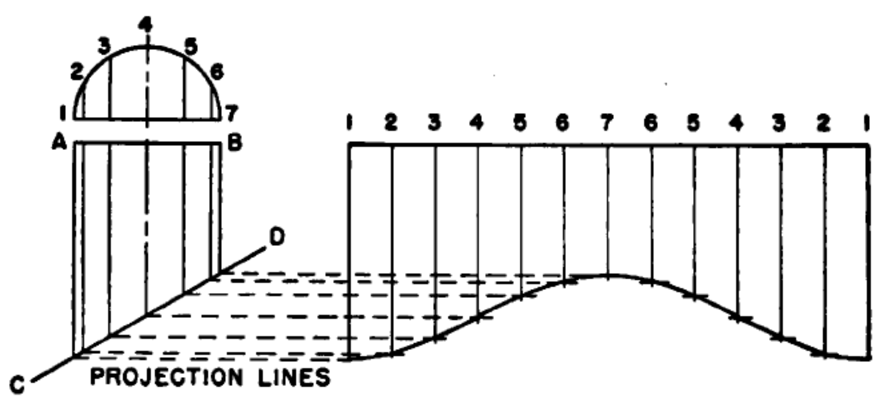


Figure 59.—Transferring from elevation to stretch-out to make the pattern.

These lines are drawn at right angles to the numbered lines and parallel to line AB. They are drawn from the point at which the numbered lines intersect the miter (line CD) to the point at which they intersect the most distant like numbered line in the stretch-out. Again, the pattern is completed by connecting the points of intersection on the stretch-out with a curved line.

Remember the more care you take in drawing your elevation, stepping off the half plan, and transferring your measurements from the elevation to the stretch-out, the more accurate your pattern will be.

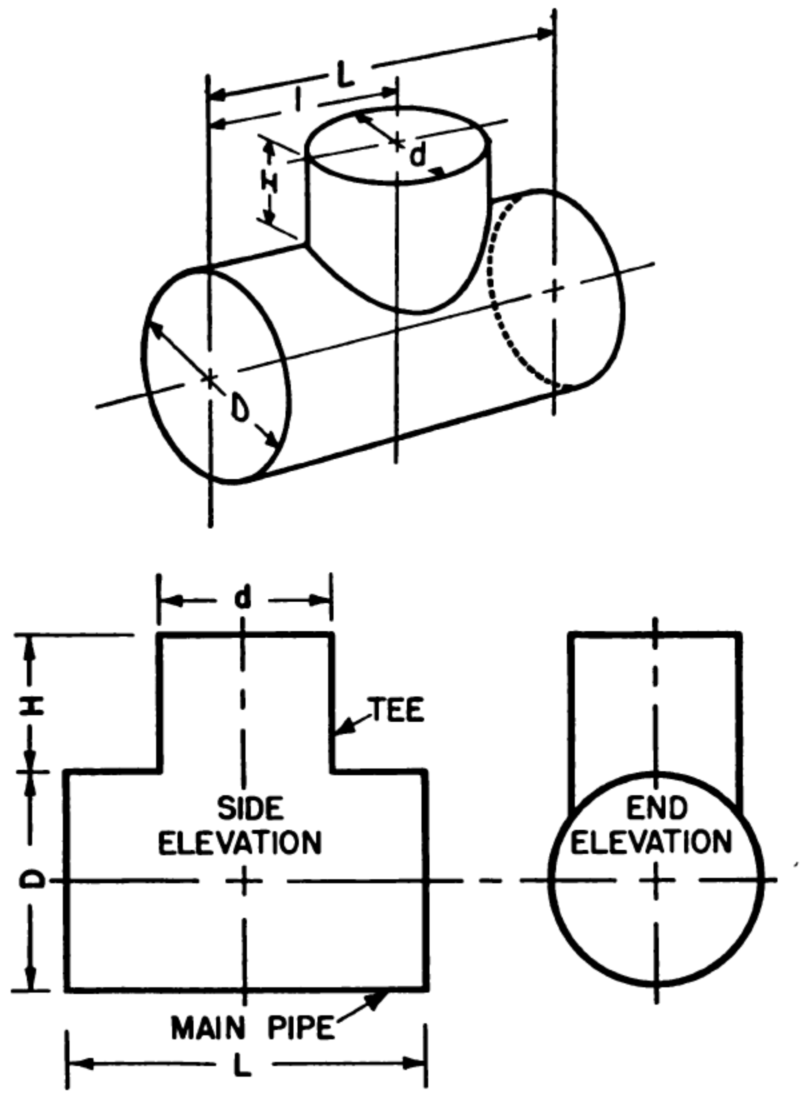


Figure 60.—Pictorial view and side and end elevation of a T-joint.

Now to use your pattern, cut it along the curved line. Allow enough material at the ends so that the pattern will lap over when it is wrapped around the pipe. Now to mark the pipe, wrap the template around it, hold it in place and mark along the edge with chalk or a piece of soapstone.

The parallel line method can be used to develop other patterns. In the pattern for a pipe meeting a rectangular tank that was just developed, it was necessary to draw only one elevation or plan view. Some developments will require two or more elevations. In the construction of tank farms there will be many times when it will be necessary to make a T-joint by welding a pipe into another at right angles.

Let's see how a T-joint is developed. To develop a T-joint you will have to draw a side and end elevation of the joint. For the side elevation you draw the T exactly as you would see it when you looked at it directly from the side. Now, imagine that you are holding the T in the palm of your hand looking at the side. Revolve it 90° toward you so that you will be looking into the end of the horizontal pipe and draw the end elevation. Figure 60 shows a pictorial view and side and end elevation of a T-joint.

To construct a side and end elevation proceed as follows:

1. Draw a horizontal center line.
2. Construct parallel lines, leaving sufficient space for the development of your side and end elevations. These lines will form the center lines for the two elevations (see fig. 60).
3. Draw the plan view above the constructed elevations (see fig. 61).
4. Step off the circumference of the plan view into equal spaces with your dividers.
5. Number the elements of the plan as illustrated. The plan is numbered 1 to 4 to 1 because each quarter section of the intersection or miter of the two pieces is the same as any other quarter section in the elevation. If the intersection of the T were other than 90° you would number from 1 to 7 as you did in developing the previous pattern.

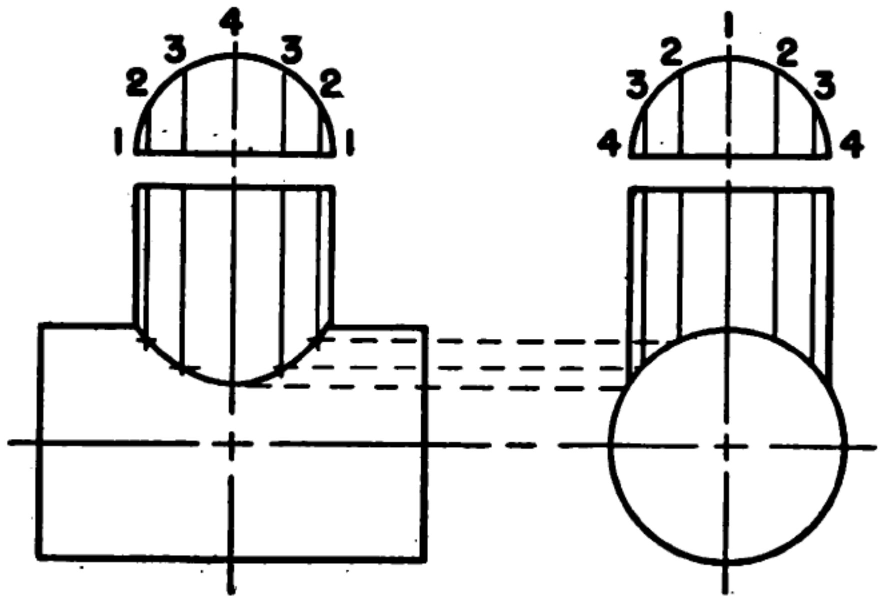


Figure 61.—Transferring elements to obtain miter line.

6. Extend lines parallel to the center lines in each of the views from the numbered points. In the end view these lines will be drawn to the horizontal pipe. To determine the lower end of the lines in the side elevation proceed as follows:
   a. Place your straightedge at right angles to the number 4 vertical element of the end view. Draw a broken horizontal line from number 4 element of the end view to number 4 element of the side view. Connect the other like numbered elements in the same manner. Remember that there are two elements numbered 3, 2, and 1 in the side elevation to be connected (see fig. 61).
7. Draw a curve through the intersections you have just located on the side view.
8. To the right of the elevations draw a stretch-out equal in length to the T (see fig. 62) or equal to twice the distance that you stepped off in the half plan. The height of the stretch-out obtained by projection is equal to the height of the T as drawn. The length is equal to the longest element in the side elevation—in this case, element number 4.

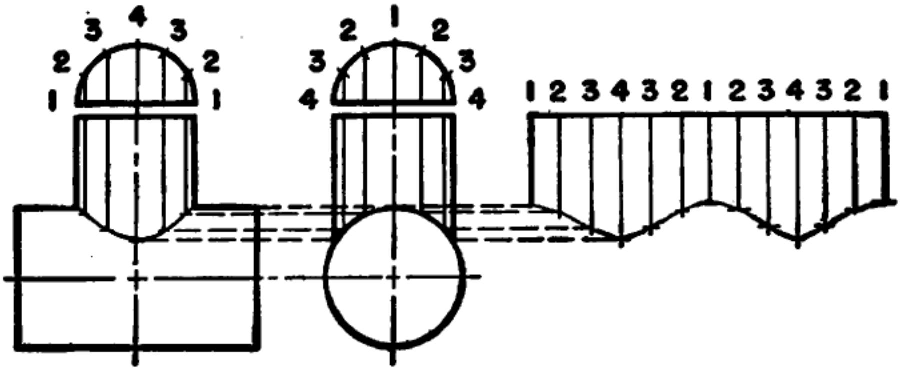


Figure 62.—Stretch-out of the T.

9. Step-off, locate, and number the element lines in the stretch-out.
10. Project the points of intersection locating the miter in the side elevation. Draw the curve through these points.
11. Now using the circumference and length of the horizontal pipe for dimensions, draw the stretch-out for the horizontal pipe as shown in figure 63.
12. Bisect the length of the stretch-out with an element line and number that line 1.
13. Set the dividers on the distance from 1 to 2 in the half plan in the elevation. Using this radius and the point at which line 1 intersects the righthand edge of your stretch-out, draw an arc on either side of 1 on the edge of the stretch-out. Number each of these points 2. Now setting your dividers for the distance from 1 to 3 in the half plan of the elevation, scribe arcs using 1 as a center on either side of element 1 in the stretch-out. Number these points both 3. Repeat the procedure to get the points for number 4 elements in the stretch-out.
14. Through the points located, draw the element lines parallel to line 1.
15. Project the elements of the side elevation view to the correspondingly numbered elements in the stretch-out. Connect the intersecting points with curved lines to outline the hole in the horizontal pipe.
16. Add space for seams to the stretch-out as required.

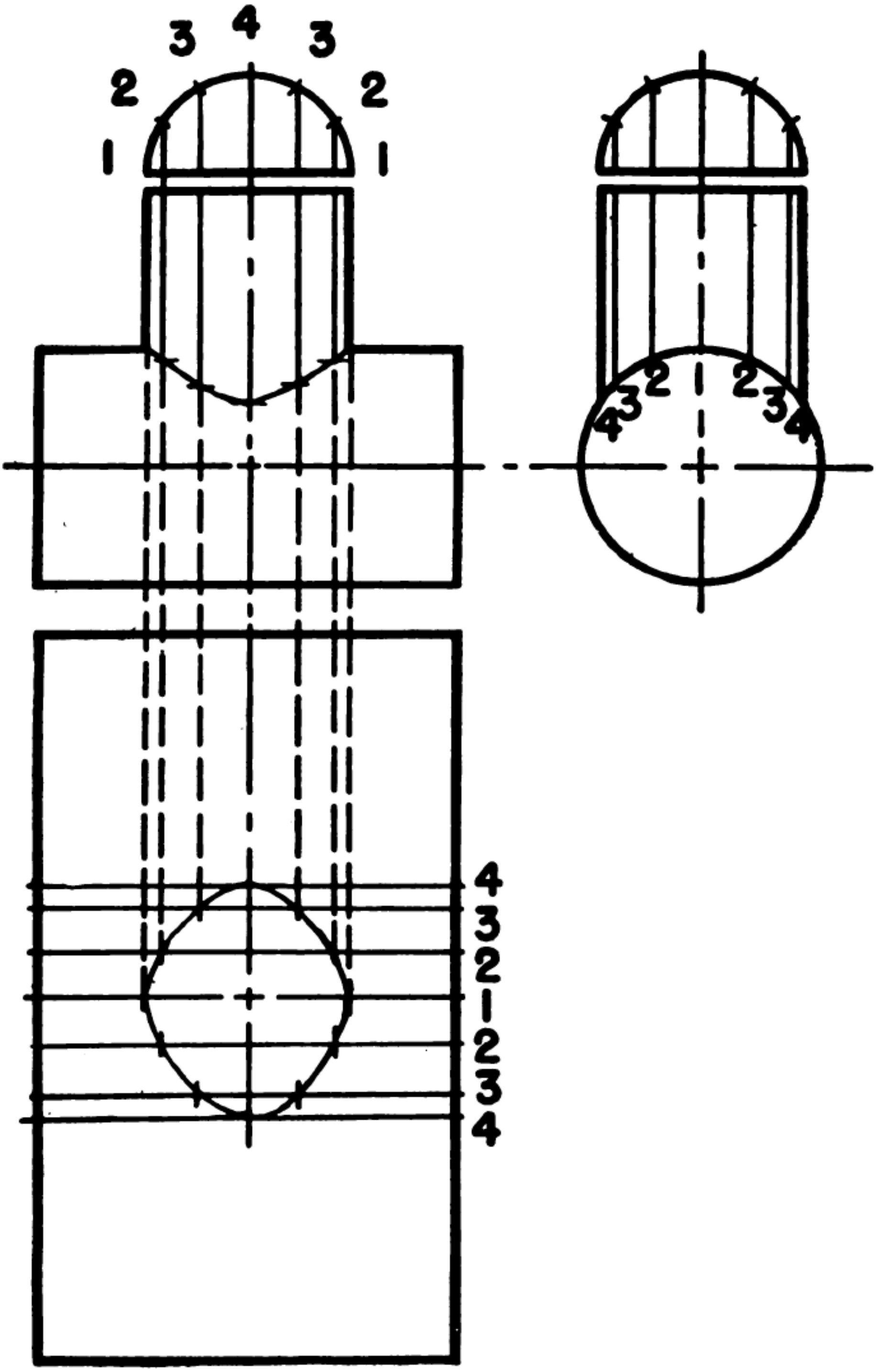


Figure 63.—Stretch-out of the horizontal pipe in a T-joint.

. . .

Now that your layout is complete, cut along the curved lines to form a template so that you can mark the pipe to be cut. You should maintain a file of pipe templates for different sized pipe. When a template begins to wear out, trace around it on a new sheet of template paper so it is not necessary to make a complete new lay-out.

STRAIGHTENING BENT SECTIONS

You can straighten bent dozer frames and other steel structural members by using an oxyacetylene torch. This method of straightening and bending steel is called spot heating. Spot heating depends on the expansion and contraction of steel for its bending force. A 12-inch bar of steel, where it is heated to the forging temperature, expands about 1/8 inch. When it cools to room temperature it contracts to its original size.

The principle of straightening or shortening a section of metal is based on controlled expansion and normal contraction. If a 12-inch bar is secured in a die so that it cannot increase its length, when heat is applied the metal will be upset. When the bar contracts as it cools, the over-all length of the bar will be less than 12 inches—about 1/8 inch shorter—as there is nothing to prevent contraction.

Figure 64 illustrates what happens if heat is applied in one spot when a shape is in a fixed position. It can't go anywhere by

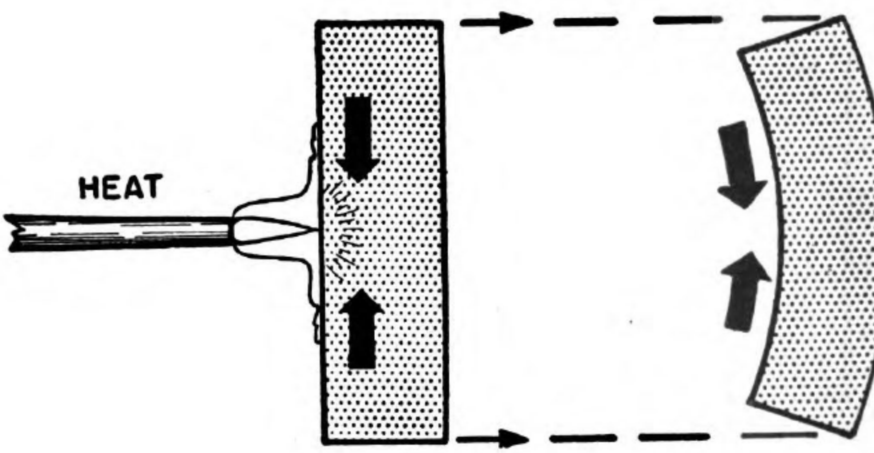


Figure 64.—Effect of heat on metal.

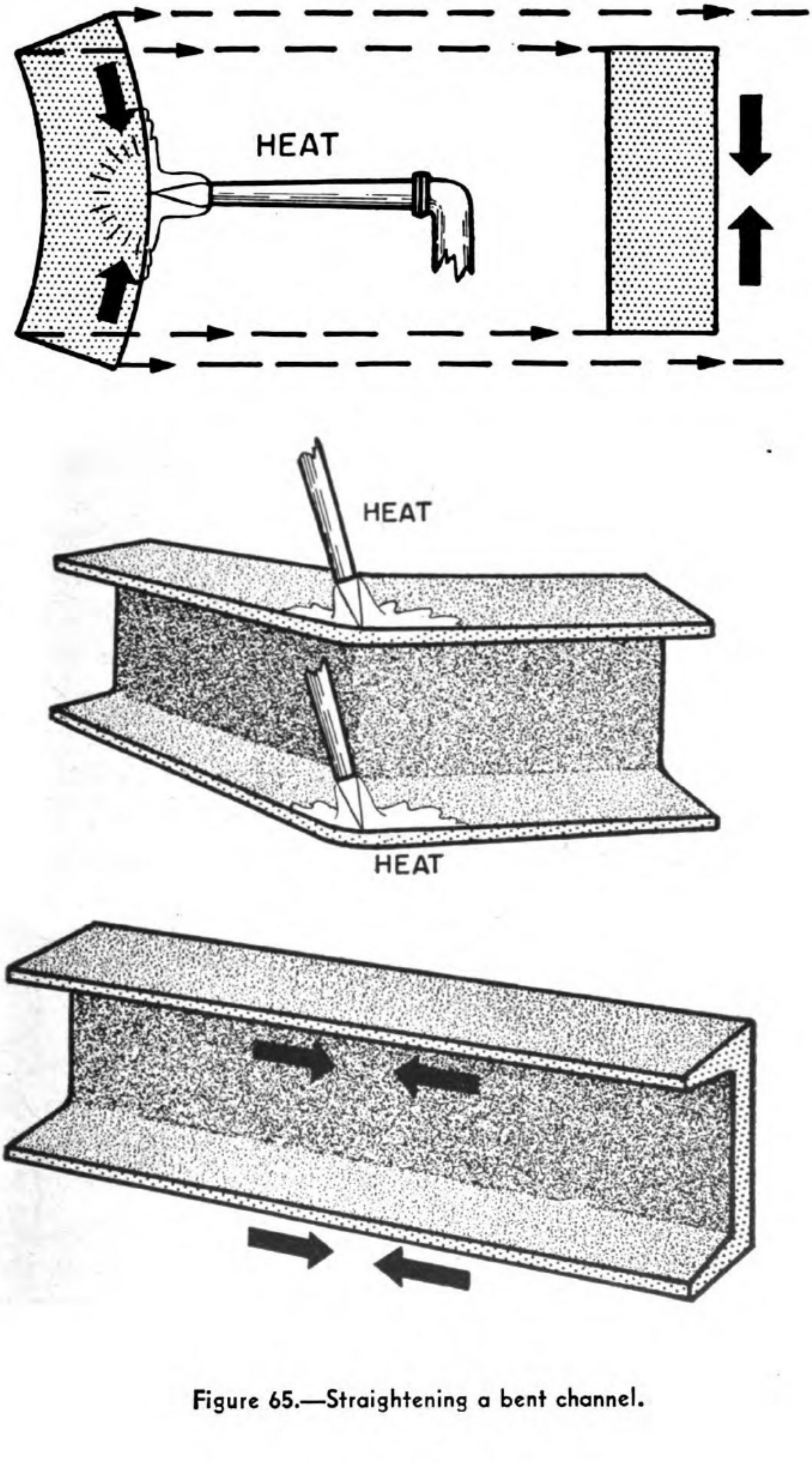


Figure 65.—Straightening a bent channel.

expansion, but the side which was heated shrinks when it cools. The result is illustrated by the warped section to the right in figure 64.

Now if you have a warped channel to straighten you would apply heat to the longer edge as illustrated in figure 65.

It all sounds very simple, but the secret is the control of heat. When heat is applied at one spot, it rapidly spreads to other parts of a bar by conduction. This spreading has to be controlled so that the metal will upset just where you want it. You can't completely control heat spread, but with proper manipulation of the torch you can keep spreading to a minimum. This takes practice.

Figure 66 shows one good way to control heat. First mark with chalk the area to be heated. Usually this will be in the shape of a triangle because more heat is required at the outer part of the bend and less toward the center. Select a fairly large welding tip for the torch you are using and hold the flame steady at one point until the metal reaches a light cherry red color. Start at the apex of the triangle or at the outer edge as shown in

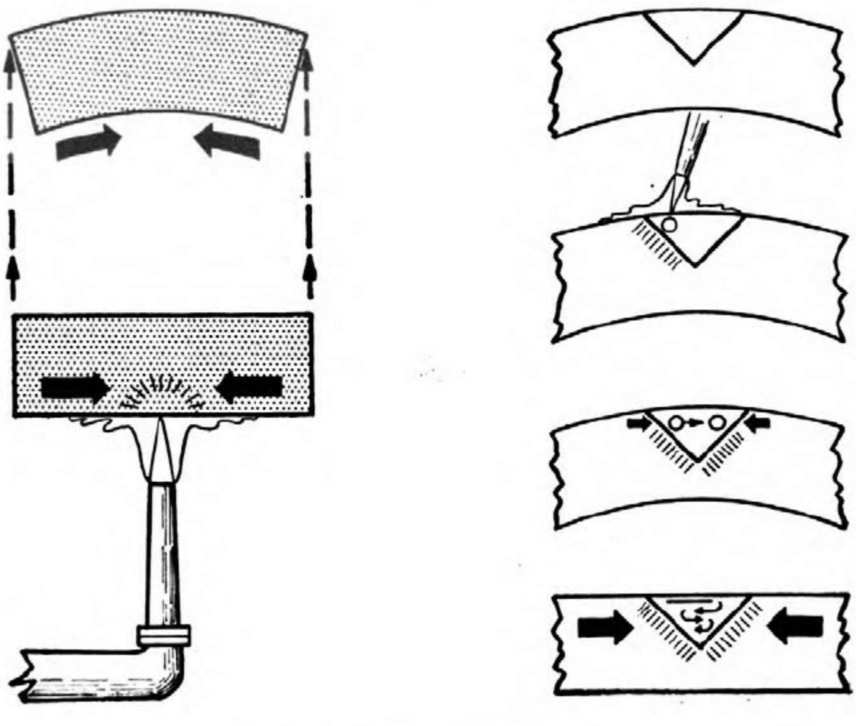


Figure 66.—Controlling the heat.

figure 66. When the small area beneath the tip reaches the proper temperature, slowly move the tip to one side so that the circular area of heated metal moves with it.

In spot heating the tip must be held steady as it is in flame cutting. Don't use the weaving motion that you would in welding. Watch the work closely and keep the hot spot moving properly. Otherwise there will be no upsetting and the metal may be burned. Under no circumstances should the metal be heated to the melting point. Continue this heating until the small circle of hot metal has covered all the area within the triangle. With this procedure you will get an appreciable bend. If the first bend is not sufficient, repeat the operation. If the first attempt bends the piece too much, straighten it slightly by applying heat to the opposite side.

Figure 67 shows how several different members can be straightened by the spot-heating method. Don't try this method on important structural members unless you have practiced and know what you are doing. If the section is heat-treated or made from tool steel, leave it alone until the entire unit can be taken down and repaired according to usual shop procedures.

It is better to apply too little heat several times than too much heat all at once. Long bends are best straightened by heating several times at intervals along the length of the bend.

This method can be used in combination with straightening by forging, hammering, and pressing. Sections to be kept cool can be wrapped in wet rags.

HARD-FACING

The cutting edge of scraper and dozer blades are tough, but in rocky soil these blades wear rapidly. The teeth of shovels, clam shells, and drag lines also wear rapidly. It will be your job to build up and resurface these parts.

The process of resurfacing parts with wear resistant metal is called either hard-facing or hard-surfacing. You may even hard-surface a blade or shovel teeth before they are put in service.

Hard-surfacing material is usually applied so that it forms a thin layer over the base metal. The thickness of the deposit is

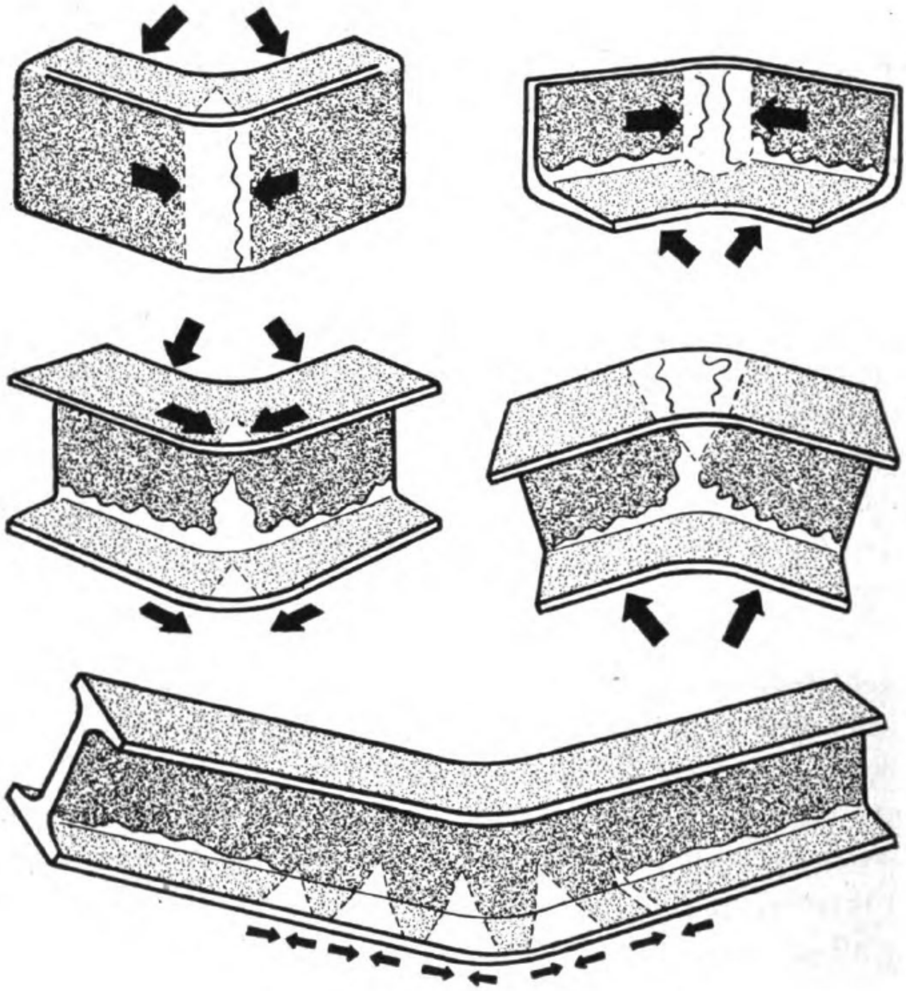


Figure 67.—Examples of straightening by spot heating.

usually from $\frac{1}{16}$ to $\frac{1}{8}$ inch and seldom over $\frac{1}{4}$ inch. Applications on small parts are ordinarily made with an acetylene torch. Hard-surfacing alloys are also available in the form of electrodes for metal arc welding.

There are three general types of hard-surfacing materials. In general, you will use iron-base alloys. These alloys contain nickel, chromium manganese, and other hardening elements. They are fused to the base metal by welding since they melt at about the same temperature as steel.

Tungsten and cobalt alloys are the second class of hard-facing materials. Those alloys are sweated to the base metal by a process similar to that used for bronze-welding.

Tungsten carbide is the third class of hard-facing material. It is furnished in the form of small cast inserts. You may weld these inserts into tools. The inserts are not melted but are held in place by weld metal built up around them. Tungsten carbide is one of the hardest man-made materials. It closely approaches diamonds in hardness.

Alloys used for hard-facing are manufactured under many trade names, such as stellite, colmonoy, blackor, manganal, borod, carboloy, haschrome, and stoodite.

Low-carbon and medium-carbon steels and low-alloy steels are easily hard-faced by either the torch or arc method.

High-carbon steels can be faced if they are first annealed. They must be heat-treated after being hard-faced. Minimum penetration is advisable.

Metal surfaces to be hard-faced should be cleaned of all dirt, scale, and rust by grinding, machining or chipping. In a pinch you can file, wire brush, or sand blast the surface. Edges or grooves, corners, or recesses must be well rounded to prevent overheating of the base metal and to provide a good cushion for the hard-facing materials.

When preheating is required for hard-facing, it is done in the same manner as for fusion welding. If preheating is required for good welding, that is your cue to preheat for hard-facing.

In some cases it is necessary to quench the hard-faced material. This should be an oil quench.

Figure 68 (A), (B), (C) and (D) shows four different methods of rebuilding and hard-facing a worn dipper tooth.

In figure 68 (A) the entire worn portion of the tooth is built up with the hard-facing material. This method is commonly used. Figure 68 (B) shows a more economical method of rebuilding dipper teeth. In this method the tooth is first built up with high carbon steel and the hard-facing is then deposited on top of the high carbon base. In figure 68 (C) most of the metal worn from the dipper tooth is replaced by cast steel or a manganese nickel repointer bar which has been welded to the worn tooth. Figure 68 (D) shows a fourth alternative which is more or less a combination method. In this method high carbon steel

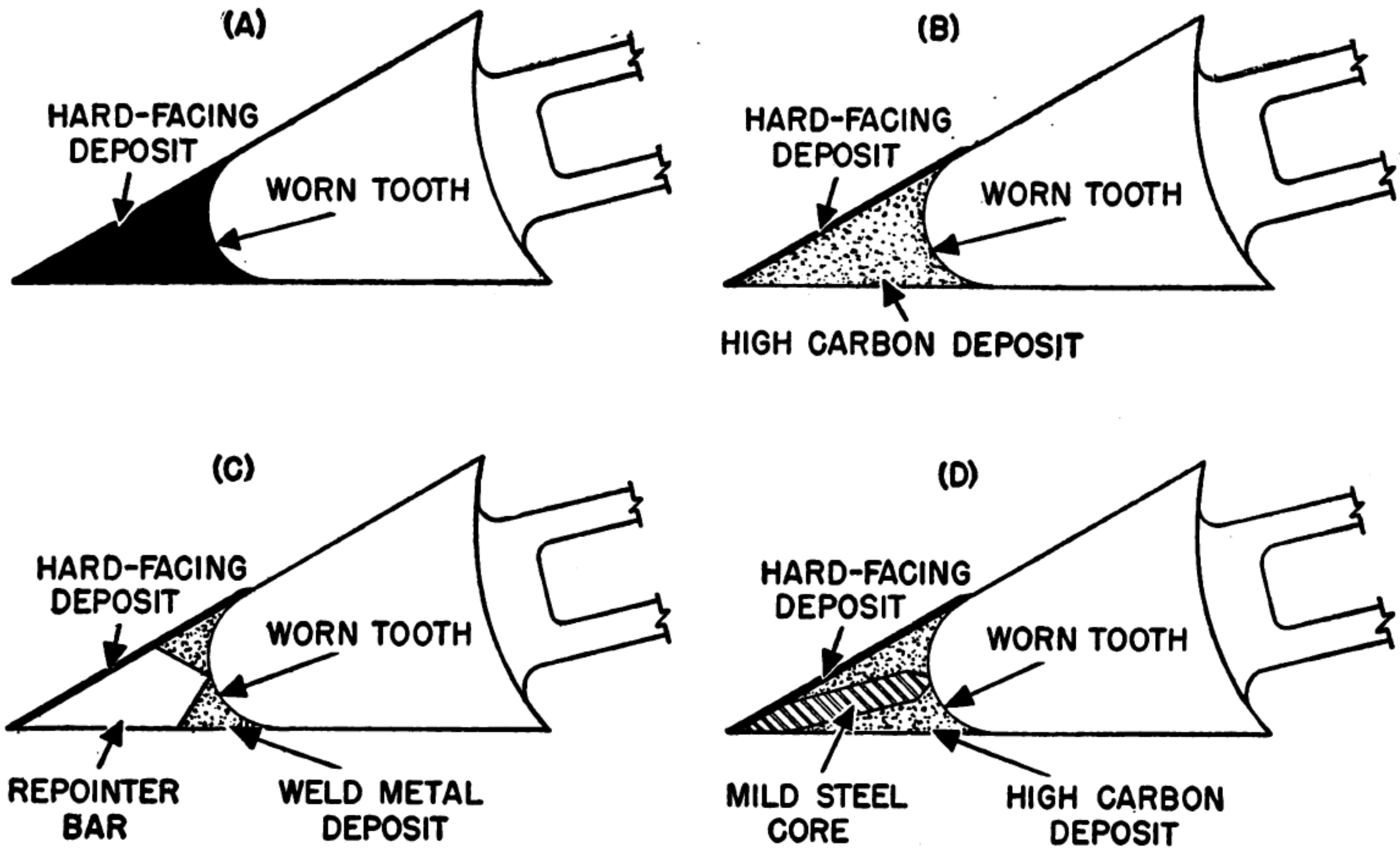


Figure 68.—Rebuilding and hard-facing a worn dipper tooth.

is deposited over a mild steel core. A hard-facing is then deposited over the high carbon to increase the hardness of the tip.

The method you use to rebuild teeth will depend on the materials available and your experience.

HARD-FACING WITH THE TORCH

You can use either an electric arc or an oxyacetylene torch to apply hard-facing. Use of the oxyacetylene flame allows close control of the hard-facing operation and produces a smooth deposit. Scale and foreign matter are easily eliminated by this method and edges and corners are readily formed. This is important when the hard-facing must be ground.

The degree of penetration can be accurately controlled with the torch. This is important because some facing alloys must be fused and puddled into the base while others are merely sweated onto it.

The torch tip size for hard-facing should be about two sizes larger than that used for welding with a welding rod of the same size.

When using an iron alloy hard-facing material the flame should be carburizing. This increases the hardness of the metal deposited.

The nonferrous hard-facing alloys are applied by sweating. Do not stir or puddle the rod. Control the thickness of the deposited metal by manipulation of the flame. Only a small area should be faced at one time.

Crushed tungsten carbide is used to make certain hard facing material. The crushed tungsten carbide particles are imbedded in steel strips or rods or are used to fill steel tubes. For application, the surface of the base metal should be melted and the hard-facing rod stirred to distribute the particles of tungsten carbide in the deposited metal.

HARD-FACING WITH THE ARC

Ferrous and nonferrous hard-facing alloys are applied to the base metal by using reversed polarity. Coated electrodes are generally used since they reduce spatter loss, assure good penetration, prevent oxidation of the deposited metal, and help

stabilize the arc. Bare electrodes may be used for heavy work.

Keep the arc as long and the voltage as high as possible. You may use the following as a general guide for current settings:

Size of electrode	Current
1/8 inch	100 to 150 amps.
3/16 inch	150 to 200 amps.
1/4 inch	200 to 250 amps.

Tungsten carbide hard-facing material may be "set on" the base with heat provided by a carbon arc. Set the welding machine for straight polarity. The process is much the same as oxyacetylene torch application of the same material.

BOLTED AND RIVETED ASSEMBLIES

As you know from experience, many of the steel structures at advanced bases are of a temporary nature. When ease of assembly and disassembly is a factor in the design of a steel structure, it is usually assembled with nuts and bolts.

Job orders should ordinarily indicate how a particular piece you are to build is to be fastened. However, if it does not, consider the possibility of bolted assembly before you go ahead and weld it up. It may be possible to build EASE OF MAINTENANCE, PORTABILITY, and EASE OF DISASSEMBLY into steel products by using bolted construction.

When bolted construction is used to assemble anything, extreme care must be exercised in the layout work. On a welded structure you may be able to cut and patch and save time and material even though you may have done a sloppy job on the layout. But if your bolt holes don't line up on a bolted job, the piece is usually ruined. And you'll find yourself starting over again with lost time and material to worry about.

Any steel structure that can be bolted, as a general rule, can also be riveted. Riveted construction is less widely used today than formerly, since it has been replaced by welded construction. However there are still occasions where rivets are used. The

same care used in making layouts for bolted construction obviously must be followed in making layouts for riveted construction.

When you are supervising or working on a job that is being riveted, the following suggestions should be followed:

1. The FAYING SURFACE—the surface between the two riveted plates must be carefully cleaned and given a protective coating of paint before the plates are riveted together.
2. The rivet holes must be FAIR (lined up). Unfaired holes must be lined up with a drift pin or reamed with a tapered reamer. When a hole has to be reamed to be faired up, a larger-sized rivet must be used. A hole that has been reamed larger than that specified for a particular rivet will not have the designed strength.
3. Prior to riveting, sections of plates to be riveted should be closely BOLTED TOGETHER. Enough bolts should be used to insure close contact of the faying surfaces. After rivets are driven in the free holes, the bolts are removed and replaced by rivets.
4. Large RIVETS MUST BE HEATED. Care must be taken to avoid overheating rivets since a burned rivet is useless. A properly heated rivet should be a light red when taken from the forge and cherry red when driven. Rivets under 3/8-inch in diameter may be driven cold.
5. When a rivet is inserted in a hole, THE POINT SHOULD NOT BE DRIVEN UNTIL THE HEAD IS SOLIDLY AGAINST THE PLATE. Before driving the point, strike the head a few blows with a hammer.
6. FORM THE POINT on the rivet by striking a series of blows around the edge of the rivet. Figure 69 illustrates a rivet properly set up for driving. The holding-on hammer is used for bucking the rivet. For removing rivets the cutting torch is your best tool.

MAKE IT YOURSELF

You will be called on to make and repair many metal articles. Before you start a repair job on a cast-iron part, it might be well

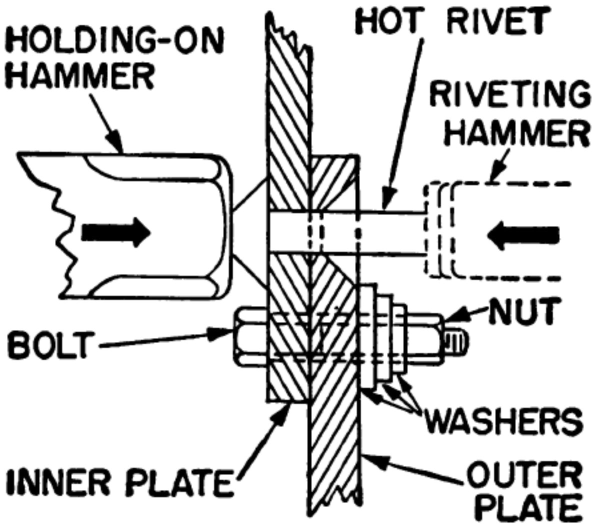


Figure 69.—Driving a rivet.

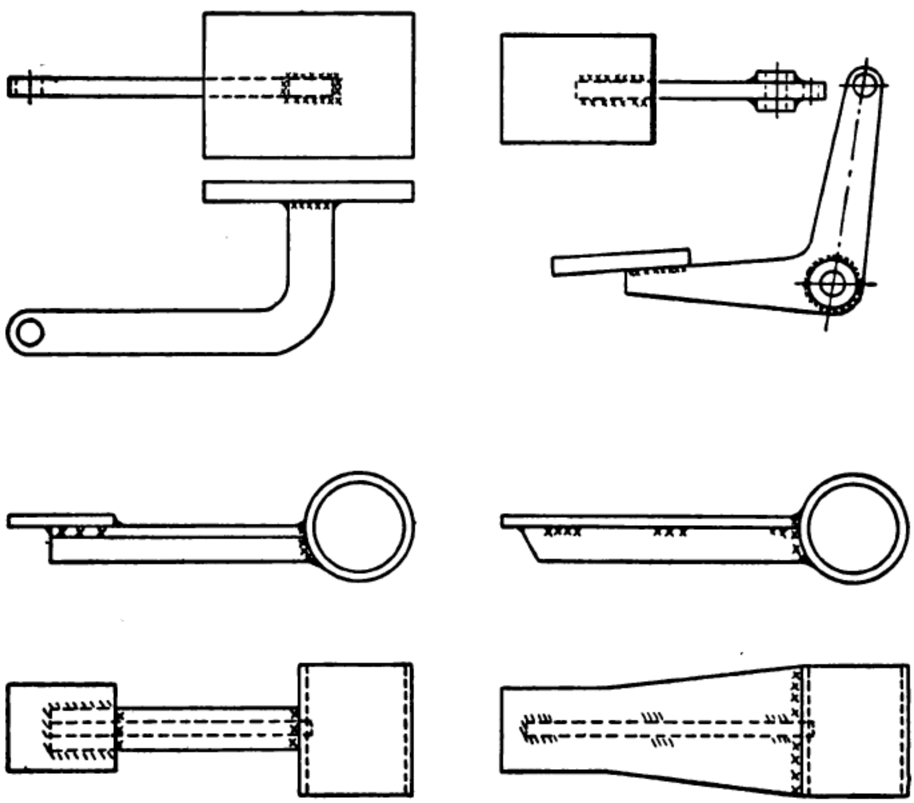


Figure 70.—Welded foot pedals.

to consider making the part from sheet steel. In industry, welded machine parts are constantly replacing heavier, more expensive forged and cast-iron parts. The physical properties of steel—high-tensile strength; superior resistance to fatigue, shock, and impact; and good ductility—far surpass these properties in cast iron.

Parts such as foot pedals, which are normally cast, can be built from steel stock, using welding techniques. Figure 70 shows several different designs of foot pedals built by welding. The next time a Driver or Mechanic brings in a broken foot pedal to be welded try your hand at fabricating one from steel stock.

Figure 71 shows a group of welded products. At some time you may have to build similar pieces as replacements for broken forgings, castings, or as parts for modifications to meet special conditions.

When you are making steel parts to replace broken castings, take your dimensions from the broken part as you make your welding layout.

Here are some points to remember when designing replacement parts.

1. Use $\frac{4}{10}$ the thickness of the cast iron when the same degree of rigidity is desired.
2. Use $\frac{1}{3}$ the thickness when strength is the principal factor and rigidity is secondary.
3. Use $\frac{1}{4}$ the thickness where rigidity is of no importance and strength is the only factor.
4. Locate important stress members to obtain maximum distribution of loads and strains.
5. Consider each component part of an assembly as an individual problem.
6. Utilize standard welded joint designs.
7. Minimize the amount of welding by bending whenever possible.

PAPER WORK

As a first class or chief you will be required to prepare work orders, job requisitions, and job completion and progress

874192°—50—10

reports. Standard forms have not been prescribed for these reports by the Bureau of Yards and Docks. The forms to be used will be drawn up by the activity to which you are attached.

When you are making up work orders or job requests the important thing to remember is to state the exact nature of the work to be accomplished. If blueprints are available, send them

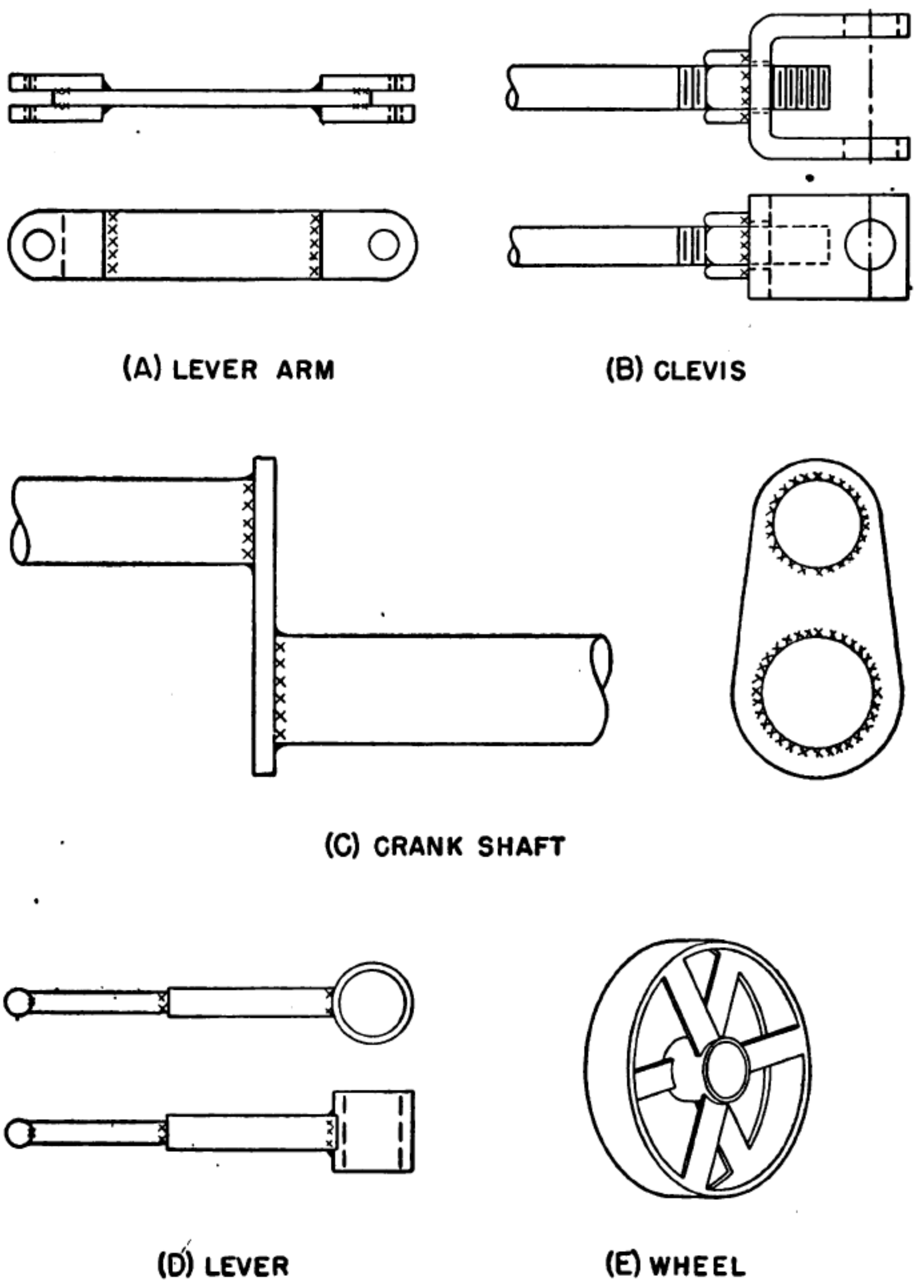


Figure 71.—Welded parts.

with the job order. In some cases a sketch is the best method to convey the information needed for successful completion of the work order.

SHOP WORK & J.O. LOG

J.O.#	DATE RECEIVED	ORIGINATOR	PRIORITY	JOB DESCRIPTION	DATE COMPLETED	MAN HOURS	MATERIAL EXPENDED

Figure 72.—Shop work and job order log.

Records are an important item in any metal shop. They need not be complicated. Figure 72 shows a simple shop work and job order log. Such records aid you in estimating the amount of material used. They are also valuable as a record of the work performed and the time spent in performing it. Your log may not be like the log shown in figure 72 but it should include the date the job was started, completed, and the material and time consumed in doing the job. There can't be any argument when your shop log is kept up to date. You have it down in black and white.

INCREASE YOUR SKILL

Layout and steel fabrication are manual skills. You will not be a good layout man after the first, second, or tenth layout. However, if you exercise care and follow the established principles, you will get layouts that fit. Try your hand at layouts and fabrication at every opportunity. Remember it is practice that counts.

QUIZ

1. You are making a layout in which the dimensions have to be held very close. With what should you mark your lines?
2. What two angles can you conveniently construct with a combination square?
3. While making a layout, you find that you cannot transfer a certain measurement with your dividers since they will not extend far enough. What layout tool will you use?
4. You are bending a piece of $\frac{1}{8}$-inch stock. How much bend allowance should you allow?
5. What is the first step in making a parallel line development?
6. On what principle is straightening by spot heating based?
7. How are the iron alloy hard-surfacing materials applied to parts being hard-faced?
8. Name the three general types of hard-facing materials.
9. What polarity is used to apply ferrous and nonferrous hard-facing alloys?
10. What is the faying surface?

CHAPTER 6

TECHNIQUES AND TROUBLE SHOOTING IN WELDING

ABILITY COUNTS

You are familiar with the basic principles underlying the process of oxyacetylene and arc welding. You have learned the safe handling of welding equipment, types of flames and electrodes, and methods of welding. As a Steelworker 1 or Chief Steelworker, you will be called on to handle welding and related joining processes that will require more skill than a 3 or 2 billet. However, ability to do advanced work in welding —tough and unusual jobs—is largely a matter of expanding upon the basic skills already possessed. Some skill and know-how will be acquired through PRACTICE. Considerable improvement will also be gained through studying this Training Course and texts of leading manufacturers of welding equipment.

There will be plenty of questions from the men under your supervision. It is no disgrace not to know the answer to every

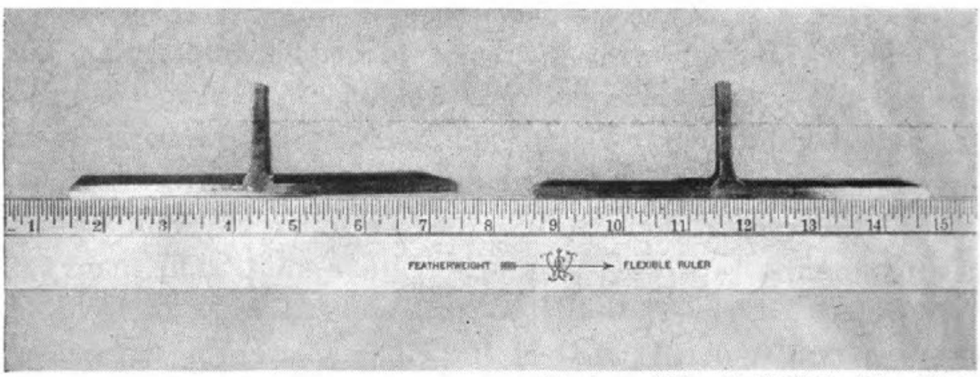
question, but you are inviting trouble if you fail to find the answer without too much delay. Just remember that you are the master craftsman, supervisor, leader, instructor, and inspector —all rolled into one. If you are to fill this billet, you must consider the problem of welding pretty seriously.

Here are some troubles that you can expect to encounter in welding, and some techniques that you can employ in overcoming them.

TROUBLE SHOOTING: Oxyacetylene Welding

Difficulties common in oxyacetylene welding are distortion, welding stress, warping, poor weld appearance, cracked welds, undercutting, incomplete penetration, porous welds, brittle welds, poor fusion, corrosion, and brittle joints.

DISTORTION is one of the more serious difficulties encountered by the inexperienced welder. There are three common causes for the distortion of the finished product; namely, shrinkage of deposited metal, nonuniform heating of parts, and improper welding sequence. Figure 73 shows an example of distortion occurring in a T-joint made from a 3/16-inch plate.



Courtesy of New York Shipbuilding Corp.

Figure 73.—Distortion.

To prevent the shrinkage of deposited metal from pulling welded parts together and changing their relative position, clamp or tack the parts. Another cure for shrinkage is peening the deposited metal while it is still warm (see fig. 74).

If nonuniform heating of parts during welding causes buck-

Courtesy of New York Shipbuilding Corp.

Figure 74.—Peening the weld.

ling before the welding is finished, and the final welding of parts in distorted position prevents control of desired dimensions, provide supports for the parts of the structure to be welded. You will find preheating desirable in some heavy structures. In some cases, you'll find it helpful to remove rolling or forming strains before welding.

If distortion occurs as a result of improper welding sequence, study the structure to develop a definite sequence of welding, or to distribute the welding to prevent excessive local heating.

WELDING STRESS is another problem with which the welder has to contend. Stresses are inherent in all welds, especially heavy parts. They may also be caused by holding the joint too

rigidly, or by improper welding procedure. In heavy parts, you can peen each deposit of weld metal, and if this does not do the job to your satisfaction, stress-relieve the finished product at 1100° to 1250° F, and soak 1 hour for every inch of thickness. You will discover that if stresses are being caused by holding the joint too rigidly, you can develop—as a cure—a welding procedure that will permit all parts to be free to move as long as possible.

Always remember that to do a good job you should make the weld in as few passes as practicable. Use a special intermittent or alternating welding sequence and step-back or skip procedures.

To avoid WARPING when welding thin plates, the following precautions should be observed:

1. Distribute the heat evenly over the full length of the seam.
2. Weld rapidly to prevent excessive heating of base metal adjacent to the weld.
3. Properly space parts to be welded.
4. Use a special welding sequence. The step-back or skip procedure may save you trouble.
5. Properly clamp the parts adjacent to the joint.

POOR WELD APPEARANCE may be caused by poor welding technique—that is, improper flame adjustment or improper welding-rod manipulation. If you expect to get good weld appearance, prepare all joints properly, use a rod designed for the job, use proper heat, and weld with a uniform weave and speed at all times.

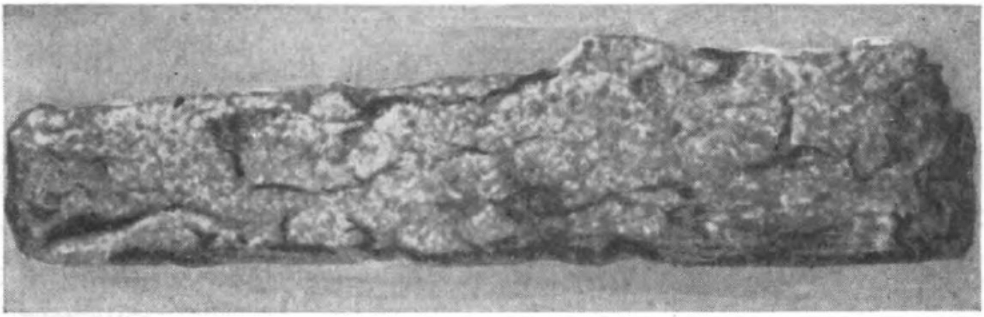
When you inspect the work of your men, you will occasionally discover a CRACKED WELD. Cracked welds are caused by using too small a weld for the size of the parts joined, improper welding procedure, improper preparation of joints, or holding joints too rigidly.

It is not enough just to tell a man why a weld is cracked or otherwise unsatisfactory. You will have to re-explain and demonstrate the procedure in order to prevent further unsatisfactory work. Whenever you find a cracked weld, it must be chipped, ground, or gouged out, and the joint rewelded.

Too much weaving of the bead, improper tip size, or in-

sufficient welding rod added to the molten puddle can cause UNDERCUTTING in the finished product. Likewise, improper manipulation—excessive and nonuniform weaving—of the welding rod may cause undercutting in butt welds. Use good welding technique—proper welding-rod deposition with uniform heating. In other words, do not hold a welding rod too low near the lower edge of the plate in the vertical plane when making a horizontal fillet weld. Otherwise, undercutting on the vertical plate will result.

One of the most common faults you will find in inspecting welds is INCOMPLETE PENETRATION. This is shown diagrammatically in the lower half of figure 75 and pictorially in the upper half of the same illustration. Causes of incomplete penetration are improper preparation of the joint, using a welding rod that is too large, a torch tip that is too small, a welding speed that is too fast, or insufficient heat.



Courtesy of Welding Engineer Publishing Co.

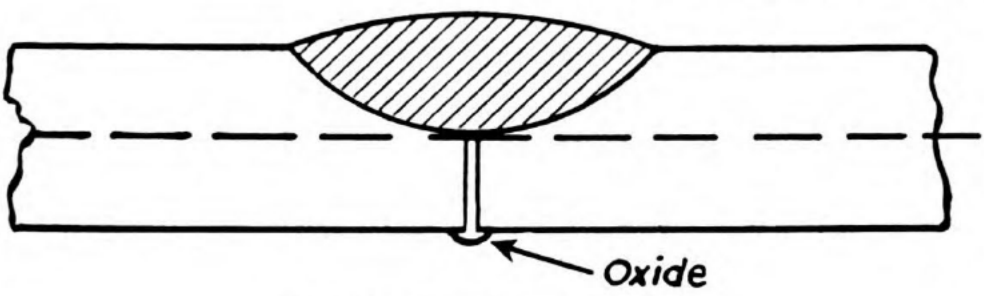


Figure 75.—Incomplete penetration.

Good instruction and supervision, with special attention to the following pointers, will help to eliminate many of the incomplete penetration rejections.

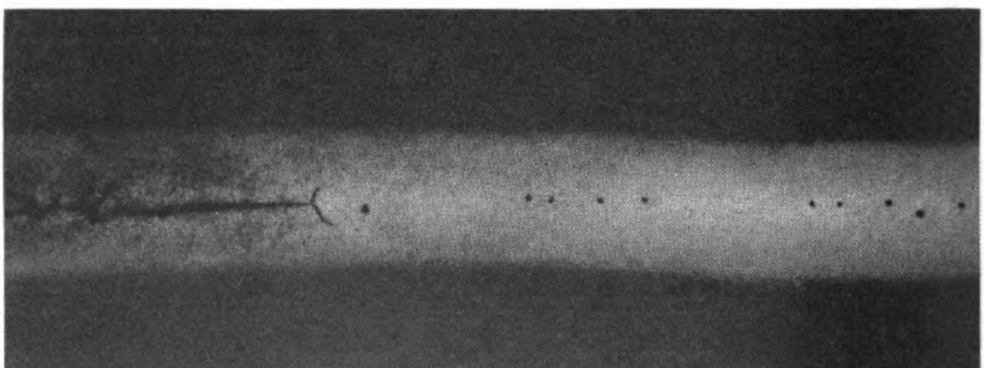
1. Allow proper free space at the bottom of the weld.

2. When you can get at the back of the joint, deposit a layer of weld metal to ensure complete fusion in the lower "V."
3. Obtain the balance of heat required to melt the welding rod, to break down the sidewalls, and to maintain a puddle of molten metal of the desired size. To obtain these requirements, the proper-sized rod must be selected. For welding narrow grooves, use small-diameter welding rods.

If you use a torch tip large enough to give you sufficient heat input for proper penetration of the plate thickness being welded, and keep your speed slow enough to allow welding heat to penetrate to the bottom of the joint, you will have no trouble with incomplete penetration.

Porous welds are frequently caused by the inherent properties of a particular type of welding rod. Be sure to choose a rod of proper chemical analysis in order to get a good solid weld. Porosity (see fig. 76) also may be caused by improper welding procedure, or improper flame adjustment. Carefully avoid overheating the molten puddle and carrying too large a puddle of weld metal. Use the multilayer welding technique. Allow sufficient puddling time to give the entrapped gas, oxides, and slag inclusions a chance to escape to the surface. If you discover that the quality of the base metal is causing porous welds, modify the normal welding procedure to conform with the requirements for welding that particular type of metal.

Brittle welds may be caused by an unsatisfactory welding rod, excessive heat input, improper flame adjustment, or a



Courtesy of Welding Engineer Publishing Co.

Figure 76.—Porosity in a welded joint.

high-carbon or alloy base metal which has not been taken into consideration.

To avoid brittle welds:

1. Do not use welding rods that produce an air-hardening weld metal such as high-tensile, low-alloy steel rods where ductility is desired.
2. Use the proper size tip to avoid coarse grain structure and oxide inclusions.
3. Adjust flame so that molten metal does not boil, foam, or spark.
4. Use a multilayer weld.
5. Be sure you know the analysis and characteristics of a steel before attempting to weld it.

Anyone is likely to get a poor weld once in a while, but if you find that one of your men is continually producing welds that show POOR FUSION, you'd better give him a bit of help. Be sure he is using the proper welding rod, torch tip, welding techniques, and method of preparing the joint.

Use rods small enough to reach the bottom of the cut when welding in narrow "V's." Make sure that heat input is sufficient to melt the rod and break down the sidewalls of the base metal. Instruct the welder to make a weave sufficiently wide to melt both sides of the joint thoroughly.

CORROSION is another of the many natural phenomena that you will be combating. You can overcome corrosion by selecting rods and fluxes with proper corrosion-resisting properties that are not changed by the welding process. Never expect more from the weld than you do from the parent metal. On stainless steels, use welding rods that are as good or better than the base metal, and for best corrosion-resistance use a filler rod whose composition is the same as that of the base metal.

You will find, too, that the metallurgical effect of welding can cause corrosion trouble. To overcome this problem when welding 18-8 (18 percent chromium, 8 percent nickel) steel, be sure the analysis of the steel and the welding procedure are correct so that the butt welding does not cause carbide precipitation (an

accumulation of carbides at the grain boundaries). To be safe, anneal the base metal at 1900° to 2100° F.

If you are working with such metal as aluminum, you'll find that careful and proper cleaning of all slag is required to prevent corrosion in the finished weld.

BRITTLE JOINTS result from using unsatisfactory welding rods, improper welding procedures, and an air-hardening base metal. Austenitic welding rods will often work on special steels, but the fusion zone will generally contain an alloy which is hard. The proper welding rods combined with proper welding procedure will help to avoid brittle joints. Welding by the multilayer method will tend to anneal the hard zones. If this method fails to produce the desired results, stress-relieve at 1100° to 1250° F. This will generally reduce hard areas formed during welding.

If your welds are made on medium carbon steel or certain alloy steels which are air-hardening, the fusion zone may be hard as a result of rapid cooling. A preheat of from 300° to 500° F should be used before welding.

TROUBLE SHOOTING: Electric Arc Welding

With a few exceptions, the troubles you run into in electric arc welding will be identical to those you encounter in oxy-acetylene welding. However, you will find some of your welders having trouble with MAGNETIC or ARC BLOW. This difficulty is brought about by a magnetic field causing a direct-current arc to blow away from the point to which it is directed. In alternating-current welding you will not be bothered with arc blow. When using direct-current, arc blow is particularly noticeable at the ends of joints and in corners. To correct this difficulty, instruct your welder to locate the ground on the work properly. Placing the ground in the direction the arc blows from the point of welding is often helpful. You may also find it helpful to separate the ground into two or more parts. Good arc-welding technique will eliminate a great deal of the trouble in direct-current welding. Hold a short arc, weld toward the direction the arc blows, and change the angle of the electrode relative to the work, and you can be pretty sure your technique is correct.

Another trouble peculiar to arc welding is spatter, that is, metal particles which are sometimes scattered around during welding and are not deposited at the desired location. Selection of the proper type of electrode which does not have this inherent property will help. Use of a short arc without excessive welding current is another cure for spatter. In general, to avoid arc-welding difficulties, observe the same rules that you follow for oxyacetylene welding with the following additions:

1. Use electrodes for welding in the position for which they are designed.
2. Use moderate welding current and do not try to weld at too high a speed.
3. Select and use the proper type of electrode for the job to be done.

WELDED PIPE JOINTS

To weld joints in steel piping you will use the metal arc-welding process. Butt joints should be used in welding joints between pipes, and between pipes and welding-type fittings, butt welding of flanges, and welding stubs. In making a butt joint, two pieces of pipe are placed end to end, aligned, and welded. (See fig. 77.)

If the wall thickness of the pipe is ¾ inch or less you can use either the single V- or single U-type butt joint. (See fig. 79.) However, when the wall thickness exceeds ¾ inch only the single U-type should be used.

Fillet welds should be used for welding slip-on type or screwed type of flanged joints to pipes, using the double fillet. These two types of flanged joints are illustrated in figure 78. With the slip-on flange (*B* and *C*), notice that the edge of the pipe is not flush with the flange in *B* and is flush in *C*. At *A*, a flange square is used to square the flange to the pipe horizontally and vertically. Screwed flanges (*D*) are threaded and a lubricant is used with them. Fillet welds are also used in welding screwed and socket couplings and fittings to pipes, using the single fillet. Before attempting to make any of these welds, familiarize yourself with the designs shown in figures 79 and 80.

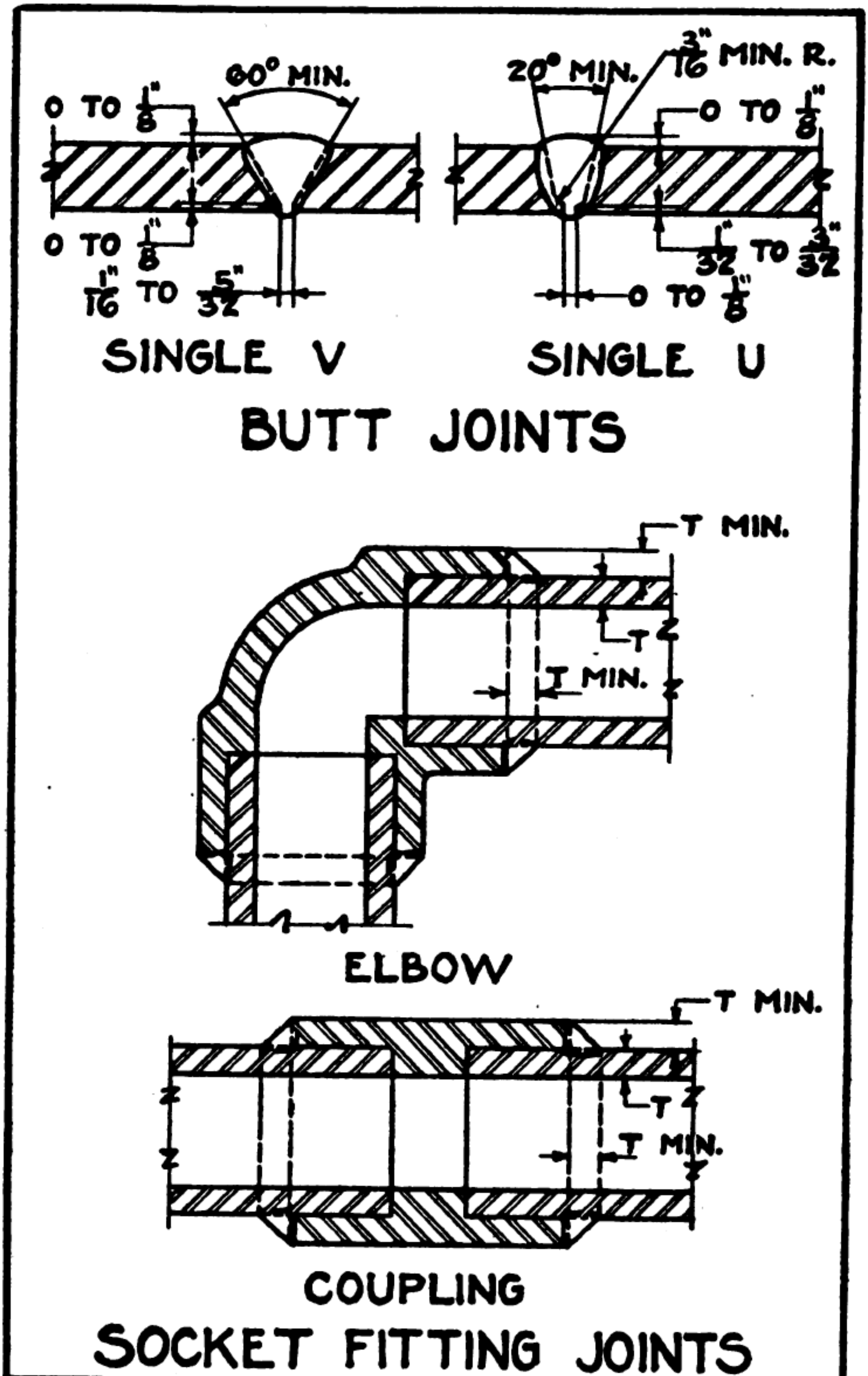
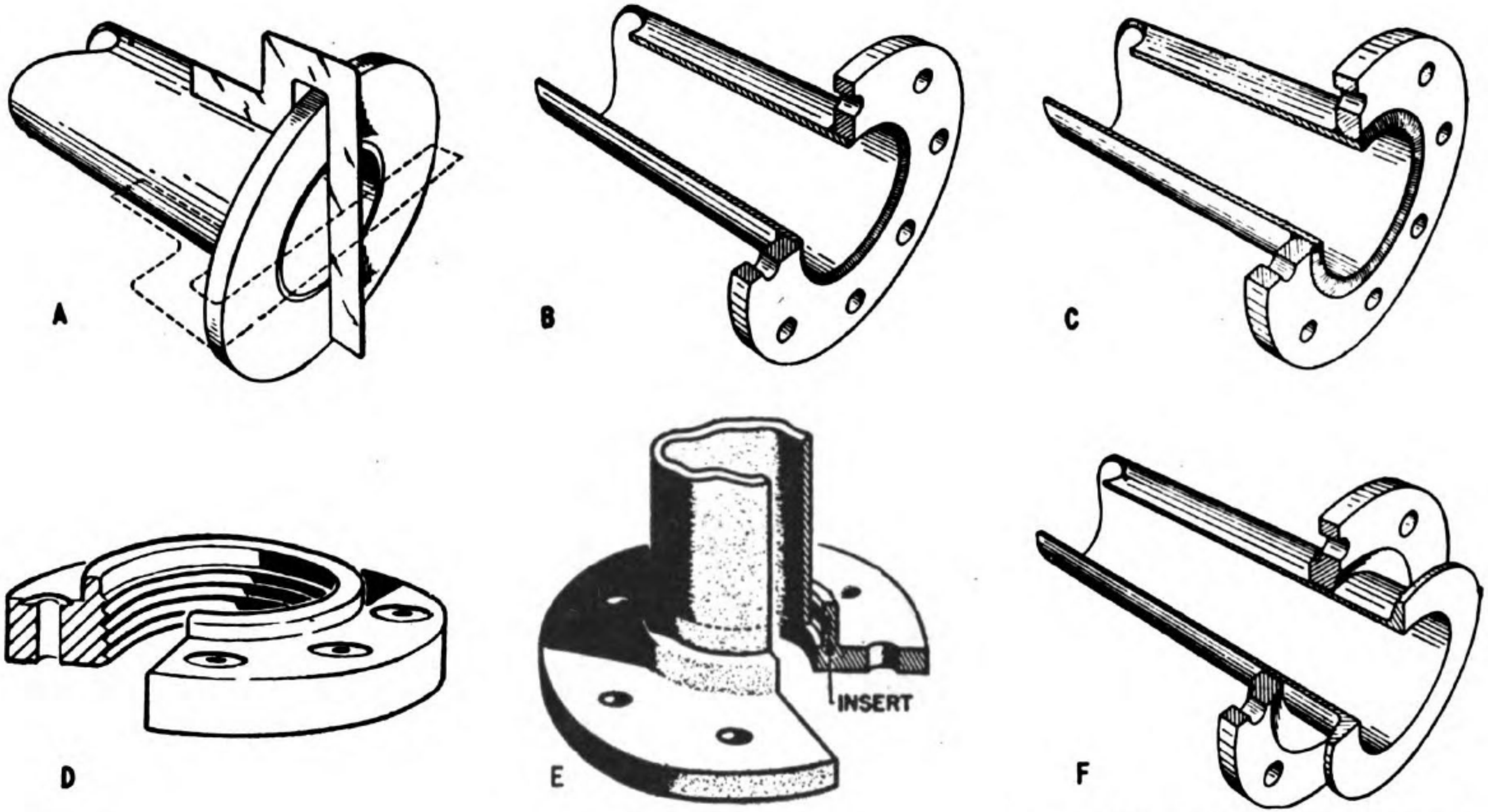
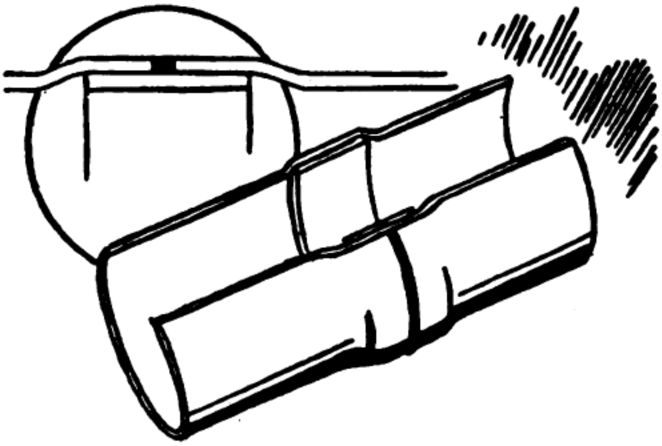


Figure 77.—Butt joint.

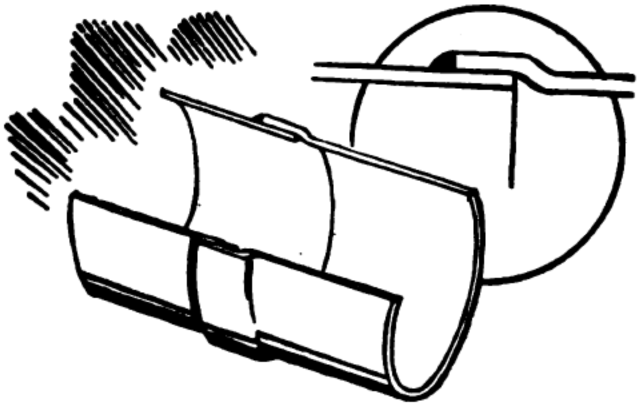


Courtesy of Crane Company and McGraw-Hill

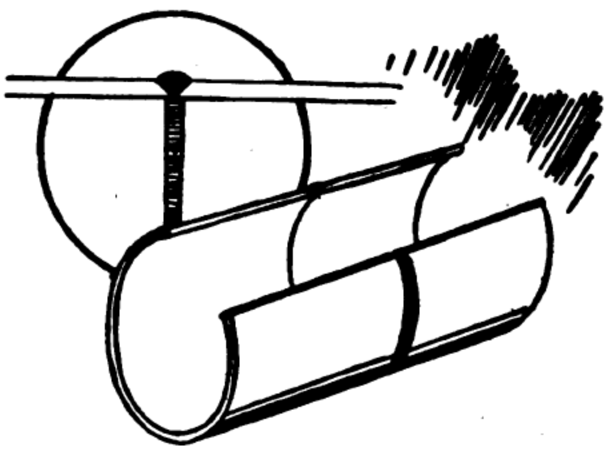
Figure 78.—Flanges.



Double-bell Joint



Bell-and-spigot Joint



Butt Joint

Figure 79.—Butt joints and socket fitting joints.

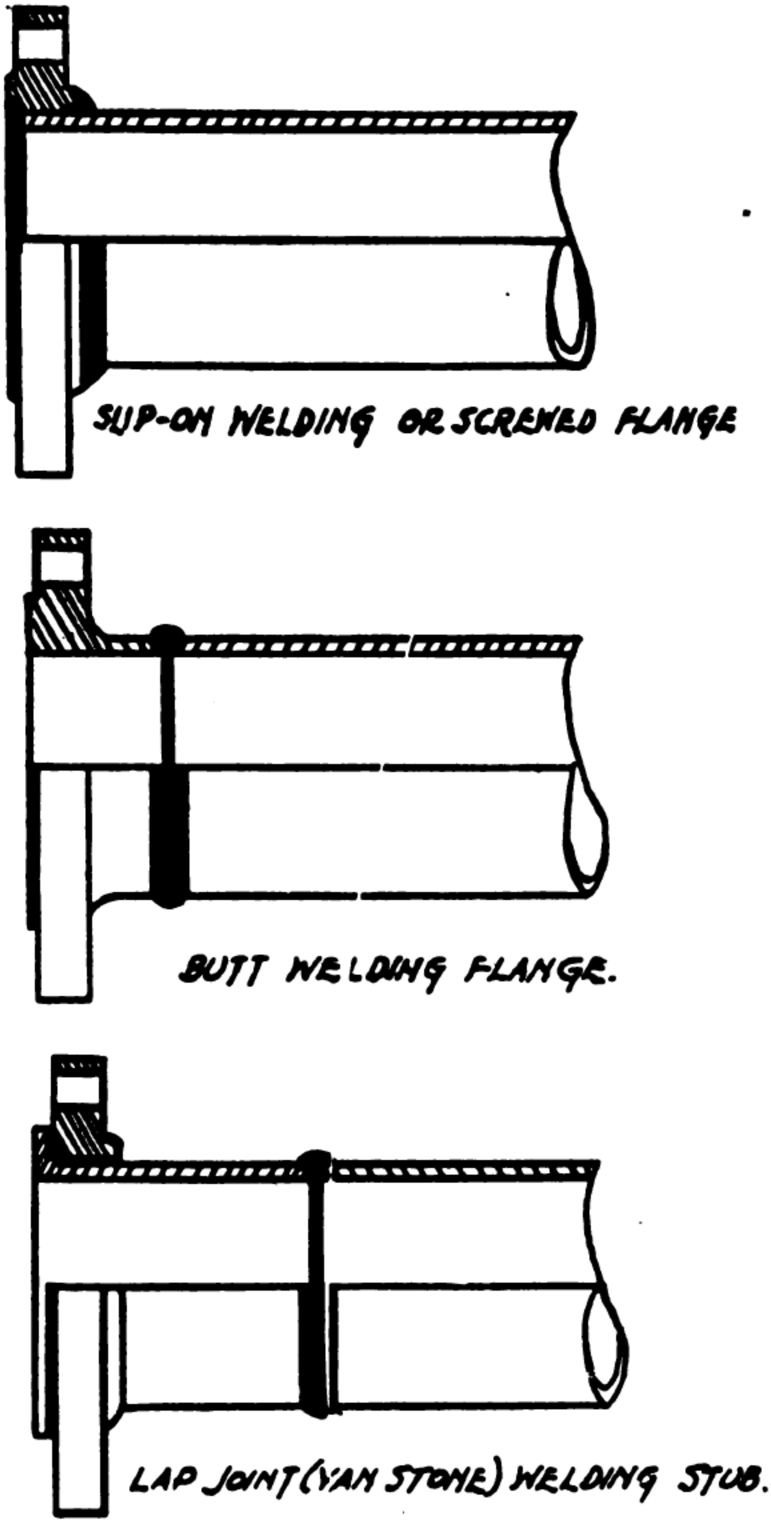


Figure 80.—Welding flanges and stub.

Seal welds, butt or fillet types, may be used to secure tightness. But keep in mind that seal welds should NOT be considered as adding to the strength of joints. Try to keep seal welds as small in cross section as practicable. Also, in making a seal weld, exercise care to avoid undue straining of joint structures.

Joint Preparation

In preparing joints for welding, remember that bevels should be cut accurately. They may be made by machining, by grinding, or by oxyacetylene cutting torch.

Make sure that surfaces to be welded are free from loose scale, slag, rust, paint, oil, and other foreign material. Also, see that joint surfaces are smooth, uniform, and free from fins, tears, and other defects which might affect proper welding. Remove any slag from flame-cut edges to be welded—but temper color need not be removed.

Unless the welder and the work are protected properly, do not assign a man to a job under these conditions: when the atmospheric temperature is less than 0° F; when the surfaces are wet; when rain or snow is falling, or moisture condensing on the surfaces to be welded; or during periods of high wind.

At temperatures between 32° and 0° F, heat the surfaces to be welded, with a torch, for an area within 3 inches of the joint, to a temperature warm to the hand before welding.

Piping should be aligned carefully before welding and maintained in alignment during the welding operation. An alignment tolerance of 20 percent of the pipe thickness may be allowed. To ensure proper initial alignment, use clamps, jigs, or other suitable devices.

Tack welds may be used to maintain alignment and root clearance. With the slip-on flange, for instance, tack-weld it—after it has been slipped on the pipe and properly aligned—where the flange and the top of the pipe meet. Keep tack welds below the outside surface of the pipe and have them not more than twice the pipe thickness in length nor two-thirds the pipe thickness in depth. Tack welds should be the same quality

as the final welds, and they should be fused thoroughly. Remove defective tack welds, if any, before making the final weld.

In addition to tack welds, spacers may sometime be required to maintain proper joint alignment. Spacers are accurately machined pieces of metal which conform to the dimensions of the joint design employed. They serve two purposes: (1) provide a means for maintaining the specified root opening, and (2) provide a convenient location for tack welds. Spacers are tack-welded so that the parts being joined are rigidly locked together.

Technique

How good a welder you are is determined largely by the techniques you employ in getting the job done. This section discusses some of the proper techniques that apply to arc welding steel piping.

The size of the electrode should be that best suited for the position and kind of welding to be done. For the root pass of a multilayer weld you will need an electrode of proper size to insure thorough fusion and penetration with freedom from undercutting and slag inclusions, but it should not exceed 3/16 inch nominal diameter. In selecting your filler metal, the guide to follow is Navy Department Specification No. 46E3 (INT).

Make certain your welding current is maintained within the ranges recommended by the manufacturers of the welding sets and electrodes, and is in keeping with the production of satisfactory welds.

Welds which cannot be made in a single pass should be made in interlocked multiple layers, not less than one layer for each 1/8 inch of pipe thickness. Deposit individual layers with a weaving or oscillating motion. See that each layer is cleaned thoroughly before you deposit the next layer. Also, make sure you avoid entrapping slag in the weld metal.

Peening

When required, peen all layers of multiple-layer welds—except exterior layers—with light blows from a power hammer, using an elongated round-nosed tool. Before peening, allow the

weld to cool to a temperature warm to the hand. Also, remove all slag particles before peening. Welds showing hairline cracks or other defects should not be peened until you correct the defects. Exercise care to prevent scaling or flaking of weld metal from overpeening.

Stress Relieving

Welded joints in steel piping will be stress-relieved when the wall thickness is ¾ inch and over and the service temperature is in excess of 250° F. Stress relieving will require heating uniformly and slowly to a temperature between 1,100 and 1,200° F, maintaining that temperature for a period in the ratio of 1 hour per inch of wall thickness, and allowing to cool slowly in the atmosphere.

For the heating operation, use one of these methods: (1) heat the complete structure as a unit, (2) heat a complete section containing the weld or welds before attachment to other sections, or (3) heat the weld by attaching a circumferential band, not less than six times the wall thickness, on each side beyond the weld, and heat the band uniformly to the temperature and for the period specified. Pyrometer equipment will prove useful to indicate accurately the joint temperature during heating and cooling. The piping should be free to move during the stress relieving.

Positions for Pipe Welding

In plate work, the welding positions are flat, vertical, horizontal, and overhead. These terms, although perfectly correct, do not adequately describe the positions for pipe welds. When you weld pipe, you will weld either in the horizontal rolled position, the horizontal fixed position, or the vertical fixed position. This terminology refers to the position of the pipe and not to the weld. The three pipe welding positions are illustrated in figure 81.

In HORIZONTAL ROLLED POSITION welds, the axis of the pipe is horizontal. The joint is made by welding in the flat or downhand position. At the same time, rotate the pipe at a rate equal to the speed of filler metal deposition. Pipe welded in this

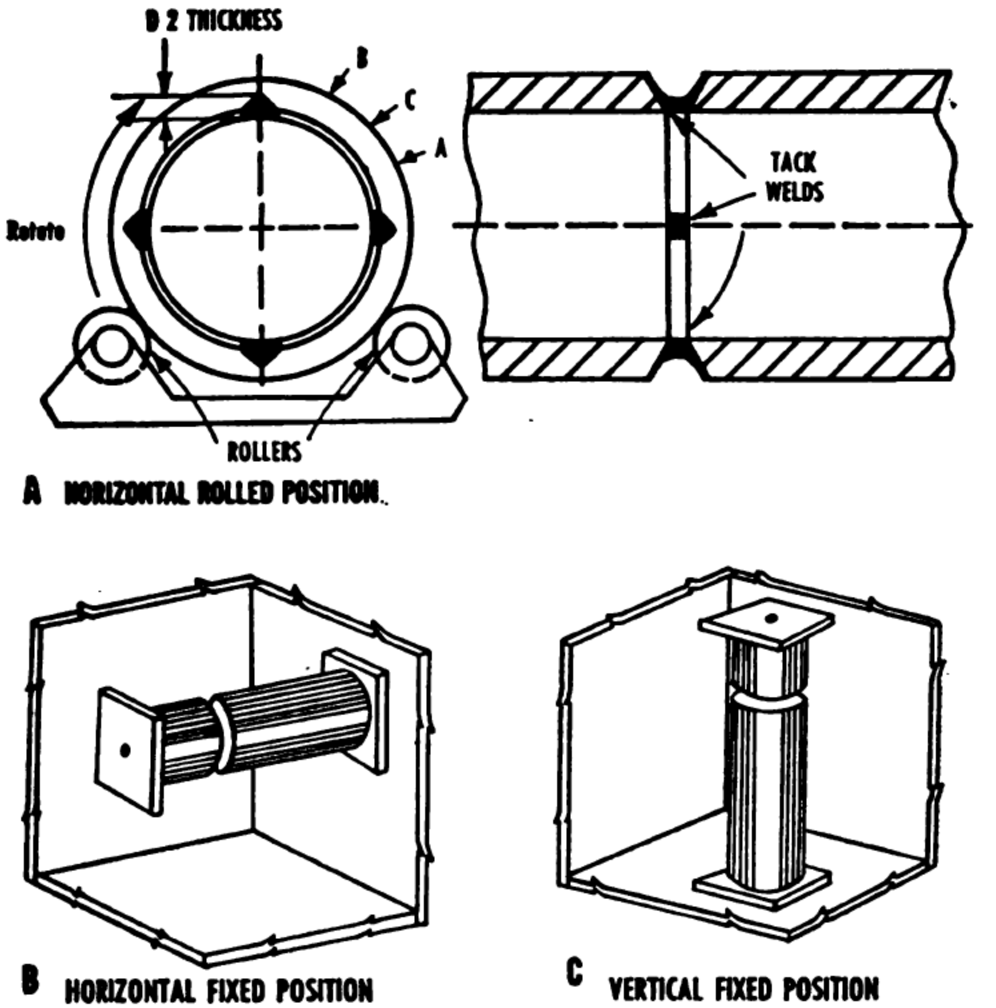


Figure 81.—Pipe welding positions.

position is first carefully aligned and tack-welded. Then it is placed in a jig (some have rollers) which facilitates rotation of the pipe. As illustrated in figure 81 at *A*, all welding should be accomplished between points *A* and *C*.

The pipe axis in a HORIZONTAL FIXED POSITION weld is the same as the horizontal rolled position weld. In this position, however, the pipe cannot be rotated. As a consequence, welding must be accomplished by progression through the overhead, vertical, and flat welding positions. When piping is in the horizontal fixed position (see fig. 81*B*), the weld is started at the bottom and progresses upward to the top of the pipe—first on one side, then on the other.

In the VERTICAL FIXED POSITION, the pipe axis is vertical and held in a fixed position. The weld itself is made in the horizontal welding position (see fig. 81*C*).

Visual Inspection

To determine the quality of welds made under your supervision you should be familiar with the visual method of inspection. This method may be divided into three separate phases: inspection before welding, inspection during welding, and inspection after welding.

A pre-welding inspection is of special advantage in that it allows you to make sure the welder is making the correct preparation for the job. It includes checking the condition of the equipment; examining the area to be welded for grease, oil, scale, or other matter which would interfere with the welding operation; and ascertaining that pipes are properly beveled and aligned.

Good results from visual inspection during welding will be obtained by observing the techniques used by the man doing the job. Watch the rod or electrode to see how it melts down. Notice the fusion and penetration. Listen to the sound of the arc. If multiple layers are being made, see that each layer is cleaned thoroughly before the next layer is deposited. In case of faulty techniques resulting in defects such as slag accumulations or cracks, make sure that corrections are made then and there—not after the job is finished.

In checking a completed welding job, watch closely to see if the welds are sound throughout, and fused thoroughly. Examine the welds for gas pockets, oxides, slag, and surface porosity. Make sure there are no defects such as overlaps, undercut, spatter, and excessive convexity. See that the inside of the pipe is free from globules (icicles) of weld metal which would restrict the pipe area, or which might become loose. Check the size, length, and location of the welds, making sure—before passing on the work—that the beads of the deposited metal are of uniform (rather than irregular) size.

This section is not intended as a complete listing of items to be covered in conducting visual inspections of welds. It should give you an idea, however, of the major factors involved

in visual inspections. The qualifications and experience of your men may require closer inspection in some instances than in others. The condition of equipment might also have a bearing on the number of defective welds. At any rate, on every welding job for which you are responsible, know in advance what defects to look for; and don't overlook any item, however insignificant it might seem.

Protection

Special attention should be given the importance of safety in welding. Consider it a major responsibility of your job as a leader and supervisor to keep your men SAFETY CONSCIOUS. In addition to posting safety precautions, orientation and constant reminders will help keep accidents on the job to a minimum. A few safety precautions are given below. Keep these in mind and, if possible, study chapter 11, "Welding and Cutting," of the *United States Navy Safety Precautions,* OPNAV 34P1.

1. Always wear protective clothing, such as helmets or hand shields which must be worn during all arc welding or cutting operations. Spectacle-type (side shielded) goggles must also be worn on these operations to provide protection from injurious rays from adjacent work and from flying objects. Gloves should be worn when handling energized holders, cables, or machines, and when removing or replacing electrodes. The gloves should be dry and in good condition.

2. Use only electrode holders which are fully insulated and in good condition. Use only those specifically designed for arc welding and capable of safely handling the maximum rated current required by the electrodes with which the holder is intended to be used.

3. Keep in mind that any electric power circuit, whether a-c or d-c, high or low voltage, is a potential source of danger. Although voltages required for arc welding are low and normally will not cause injury or severe shock, they are strong enough to be a potential source of serious shock under unfavorable conditions.

4. When flammable or explosive materials will be exposed to welding or cutting operations, see that a fire watch is posted in that vicinity. Fire watches should be posted on both sides of

a deck, bulkhead, wall, or ceiling being worked on, if fire hazards exist on both sides. Require that the fire watches remain at their stations for a reasonable time (at least 30 minutes) after the job is completed to ensure that there are no smoldering fires.

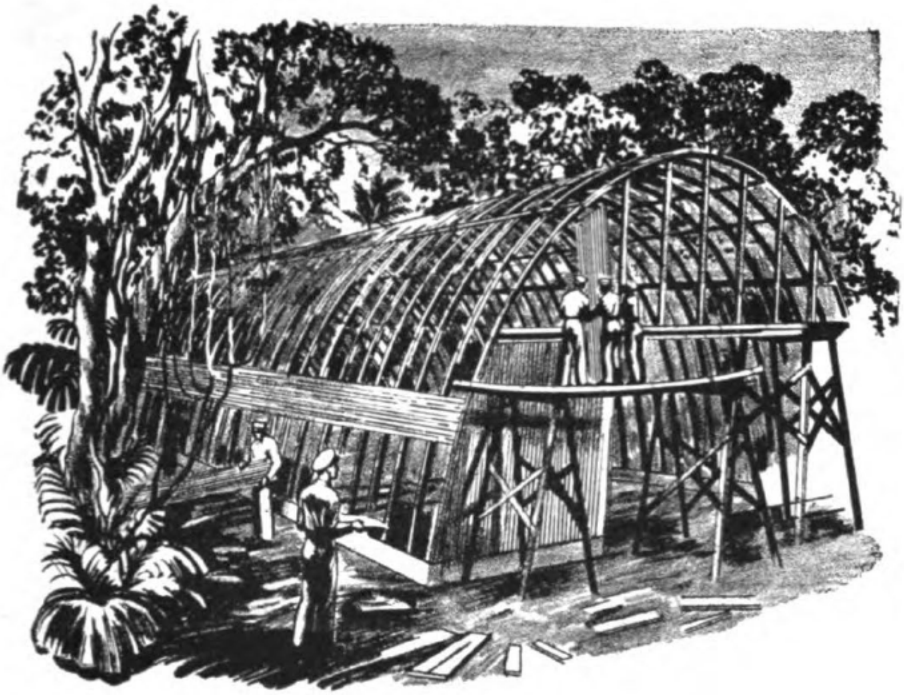
5. Where a welding operator must enter a confined space through a manhole or other small opening, means should be provided for quickly removing him in case of emergency. Safety belts and lifelines used for this purpose should be so attached to the operator's body that the body cannot be jammed in a small exit opening.

6. Welding equipment should be maintained in good mechanical and electrical condition to avoid unnecessary hazards. Commutators should be kept clean to prevent excessive flashing.

7. Always make sure that suitable fire-extinguishing equipment of approved types are maintained near all welding and cutting operations.

QUIZ

1. Name three common causes of distortion in a finished weld.
2. How may cracks be prevented in oxyacetylene welds?
3. Name the causes of incomplete penetration that may be encountered in oxyacetylene welding.
4. In addition to the rules for proper oxyacetylene welding, what rules should be observed for satisfactory arc welding?
5. When are butt joints used in welding pipe joints?
6. For what purpose would you use seal welds in pipe joints?
7. How are bevels made?
8. What two purposes are served by spacers?
9. Name two results from overpeening.
10. When is stress relieving of welded joints in steel piping necessary?
11. When will a fire watch be needed in the vicinity where welding or cutting operations are to be done?
12. Name three positions in which pipe welds are made.
13. When a pipe joint is welded in the horizontal fixed position, at what point is the weld started?



CHAPTER 7

SUPERVISION

NEW RESPONSIBILITY

When you advance to first class or chief your supervisory duties will become increasingly important. More of your time will be spent in directing and leading the work of your crew and you will spend less time working with your hands.

By now you have probably worked under a number of leading petty officers. Most of them were good supervisors, or they wouldn't have been leading petty officers, but you can probably remember several who were outstanding. Look back and try to discover what made you and the rest of the men work harder, longer, and more willingly for those men. Sure, they were good guys, and you liked them, but there was more to it than that. Those men weren't born outstanding petty officers. They had learned certain fundamentals that they observed in their contacts with the men under their supervision.

The following pages should help point the way for you to assume your new responsibilities.

PLAN THE JOB

One of the first factors affecting supervision is an adequate job plan. Before you can begin to supervise a job you must know what the job is and lay the ground work by formulating a job plan. This was pointed out in chapter 5. Without a clear-cut plan you will just be muddling through. Know what the job is. Know how you are going to accomplish the job. Know the number of men required. Know the tools and materials necessary. Take all factors that apply to the particular job into consideration, and when you arrive at the right answers, you are ready to get started.

KNOW YOUR MEN

You must know your men. Not just that the man with a wrench in his hand is Joe Kink, Constructionman, but much more. The men in your crew aren't just so many warm bodies. If you consider them as such you will end up with just so many individuals instead of a coordinated, work-producing crew.

Every man is an individual and must be treated as such. Men in the Navy have all kinds of backgrounds. There is no typical sailor. "All men are created free and equal" according to the Declaration of Independence, but a lot has happened to them by the time they become members of your crew. One may have been reared in the competitive lower east side of New York. He knows his way around; he had to learn to get along with others. Another may have come from a sleepy southern farm. There will be wide educational differences between members of your crew. There will be mental differences too. One man may be sharp. He doesn't have to be told twice. He grasps the problem when you give him the barest outline. Another may be a bit slow. For him things will have to be explained slowly, clearly, and perhaps repeated several times.

You will have to deal with sensitive men and "thick skinned"

men. You can't treat them alike. A mild rebuff will have no effect on the "thick skinned" individual. The sensitive man will respond to your suggestion but will resent a rebuff.

Besides these, and many other personal differences, you should know the skills possessed by your men. If one is a fast man with a splice but a slow man with a torch, you should know about this so you can give him more practice in welding. However, don't overlook an opportunity to call on him for an emergency splice in a cable, when the occasion arises.

You can't set yourself up in an "ivory tower" and expect to get to know your men. Merely professing to be interested in your men isn't going to get you anywhere either. If you are really interested you will get to know them. Be a good listener. Ask that Southern boy where he got his accent. He'll probably give you a long story about his home in North Carolina. You'll know him better, and what's more he will know you are interested in him.

There are many ways you can get to know your men. Watch them at work. Join in their ball games and other athletic contests. Chat with them when they assemble around the "Joe" pot for that midmorning cup of coffee. Make yourself available for discussion of personal problems. Perhaps you won't be able to help the man, but he will feel better after he has discussed it with you. Perhaps the man's problem can best be solved by a visit to the chaplain or medical officer; if so, you are the man to send him on to the proper person.

You will build some lasting friendships while you are in the Navy. It would be rather strange if you did not. Friendships in themselves are fine, but they bring up the problem of favoritism. You can't be a good supervisor if you play favorites. If you give one or two men all the breaks you will soon have a disgruntled, uncooperative crew. They will be quick to see that effort on their part is unrecognized. You won't be doing your friend a favor either, since the men will soon have them tagged as "ear bangers" and life can be made pretty miserable for an "ear banger."

It's a perfectly natural inclination, a part of every man's make-up, to give the breaks to the people he likes. The

important thing is to realize that you have the inclination and control it. When you have a specially good detail to fill or a privilege to grant, you had better think about the reason behind the choice you're making. Let ability be the measure of your men. Choose a man you don't like if he is more competent. Your men may not like him either, but they know he is qualified for that detail. If he doesn't get it, they will lose confidence in you, and consequently they'll lose interest in their jobs. Don't give your men reason to believe that the only way to get ahead is to become your pal.

You can't allow friendship to interfere with your duties as a supervisor. You must act IMPERSONALLY. Often this is difficult to do, but it's absolutely necessary. You won't lose the man's friendship, if he is the kind of friend worth having.

Impartiality isn't a rare and miraculous quality, but simply the result of thinking a situation through to a sound, logical conclusion.

FIT THE JOB TO THE MAN

After you know your men, you won't gain any advantage unless you put that knowledge to work. You have learned about him as an individual. Now treat him as one. That does not mean coddling him or protecting his tender feelings. This is still a man's Navy even though we do have the Waves.

Your job is to make every man a competent hand. But your methods will prove a lot more successful if you suit them to the individual. A deck court has less effect on some men than a "bawling out" has on others. If you go into an unnecessary long-winded explanation to a quick-witted man you'll irritate him; but if you don't explain very carefully to the slow learner, he'll become hopelessly fouled up. Some men perform best when acting in a position of responsibility; others prefer to follow. You must be the judge. Decide what your men do best, and assign them accordingly.

Understanding your men enables you to assign them to the details they are especially well fitted for. It helps you to get to the bottom of the trouble when a man seems to go sour. The net result is good morale.

To help get the right man on the job, the Navy has developed a system of job classification. You and every enlisted man in the Navy has a NAVY JOB CODE or codes. This code(s) indicates the job(s) a man is qualified to perform. By obtaining a new man's job codes and looking them up in the *Manual of Navy Enlisted Classifications,* NavPers 15105 (Revised), you can quickly find out for what jobs he is qualified.

AS GOOD AS YOUR WORD

To be an efficient supervisor you must be reliable. When you make a promise or threat be sure that you can follow through and carry out your word.

Promises are good incentives if you can carry them out. The outfit will work harder if you promise them extra liberty on completion of the job. But before you make the promise be sure that it is entirely within your power to carry it out. A complete understanding with your immediate senior, either petty officer or commissioned officer, is absolutely necessary to give your decisions the force they need to seem important to the men. No one is more disliked than the PO who promises special privileges for a special detail and then, when the chips are down, can't produce.

An unkept threat is as dangerous as an unkept promise. Even small children soon run wild if threatened with punishment and never punished. Unless a joint policy is established between officers and petty officers you may find yourself bound hand and foot when you want your men to complete an unpleasant assignment. An SW1 who has threatened to stop all liberty, when he had no authority to stop anyone's liberty, looks pretty foolish watching his men walk out the gate with liberty cards issued in spite of him. No PO should get the idea he has the authority to stop liberty as a punishment. Only the commanding officer has that authority.

Promises and threats are easy to make. They can be made to save time, to avoid argument or explanation, to postpone a decision with the thought in the back of your mind that you will be able to wiggle out of the situation—you can make them with the

best intentions then forget them. But for every promise or threat not kept—no matter how small—YOU HAVE LOST THAT MUCH CONTROL OVER YOUR MEN. They are experts in detecting phonies and there is nothing phonier than the PO who welshes on his word.

Think of a promise as equal to a commitment made in writing, signed, and witnessed. This will make you less likely to use a promise as an easy solution to a problem. If you can't promise to fulfill a reasonable request from a man, try to explain why. But it's better to say "No," without an explanation than to give a promise you know can't be carried out. When you do promise something, you must be willing to go all the way to carry it out. Thus you can build a solid foundation of confidence.

Once you are sure that a man is making a reasonable request or a justified complaint, you must be ready to go to bat for him. The men will respect you for it and so will the officers. Of course, you should check the facts before you go out on a limb for a man. Make sure that the complaint is a BONA FIDE one which should be investigated and on which action should be taken. In this way you will acquire a reputation for reliability and fair dealing.

The officers you deal with will soon recognize that you come to them with only legitimate complaints and requests, and will give them the consideration they are entitled to.

Loyalty to your men means more than "sticking out your neck." Often it means hours of extra work and personal sacrifice. For example, your rigging crew is given the job of moving a heavy piece of water purification equipment into place in the shelter just built for it. It's a rush job, but as the day wears on it becomes increasingly obvious that the job cannot be finished till late that night. The PO in charge rates liberty and has plans. Should he leave his men to finish the job, or stay to see it through? This is a matter of common sense and personal decision. The PO in charge decides to stick with his men. He arranges for lights, splits his crew into two shifts for evening chow, and applies his rigging experience to speed the job. Even then the job isn't finished till past midnight, but the PO has other details to attend to. He has to request the OOD to let his

men sleep until breakfast the next morning and he has to see about special liberty for them. The PO may have missed a good liberty that night, but he has gained a devoted crew.

PASSING THE WORD

In the Navy a man obeys the order of his lawful superior or becomes liable for punishment. Some supervisors operate entirely on this basis. They will tell you there is just one way to get a job done and that is to give the command and then keep driving until the job is finished. They ignore a truth known to every good supervisor; a man does better work when he understands the purpose of a job and has a share in the planning of it. Your men will forget discomfort and ignore danger if they feel that what they are doing is important.

How do you make it important to them? By showing them that their job is an essential part of something big. For this reason you must keep your men as well informed as possible about the general plans of the activity of which you are a part. If they know what the activity is doing and why, they'll understand better what they are to do. Show your men the reason for their duties when possible. Make clear how those duties fit into the big picture.

During the last war there were innumerable instances of increased efficiency directly traceable to the men's personal interest in and understanding of their work.

You have all heard of the amazing feats of airfield construction accomplished by CB units in the Pacific. Those same CB's had Jap planes dropping bombs on them almost every night. The war was a very personal thing to them. So they put every effort toward establishing bases from which our planes could operate and end the menace of Jap aircraft.

Of course, during the war most men were personally interested in the job at hand. During peacetime it will be your job to point out the importance of their duties as training for war and as a necessity for maintaining high operating efficiency in the naval service.

If you can, let your men feel that they share in the responsibility for the job. In other words, when it's up to you to figure

out how to accomplish a piece of work, share your problems with your men. As soon as it becomes their problem, they tackle the job with enthusiasm because they feel it depends on them. You have appealed to their intelligence. This pleases them and they will work more intelligently for you.

You get something better than mechanical obedience—you get smart and willing cooperation. Your men make the suggestions, but you make the decisions. The final responsibilty still rests on your shoulders.

There are other incentives to good work. They don't take the place of your official authority as the petty officer in charge of a job; but every good supervisor uses them. For example, an SW3, momentarily disgusted with his job of welding some small tanks, turns out a sloppy job of welding. The PO in charge of the job tells him to do it over but adds that it is poor work to come from a good workman. In this case the PO appeals to the SW3's pride in his skill. Every man with a skill has that pride. When you appeal to it you get the best he has to offer.

The competitive spirit is also a strong incentive that will help you get things done. Give a man something he can beat—his own past record, the record of a shipmate or another section or another battalion—and the chances are that he will work his head off. A group of CB builders will put up a large warehouse in 3 days to beat a record established by aviation engineers who have taken 4 days to erect the same type of building. Make competition work for you. It can add zest to an otherwise dull job.

WORKING CONDITIONS

Men do their best work when their living conditions are pleasant and when their duties don't involve a lot of unnecessary discomforts. You may have heard the story about a certain CB battalion in the Pacific during World War II that from all reports seemed to be going to "pot." They were slow to accomplish the jobs given them, morale was bad, and they appeared to have an excessive number of men constantly on the sick list. An inspection of their camp disclosed that it had grown knee deep with weeds, the galley was dirty, the cooks were sloppy, and

there was a mountain of tin cans behind the galley. The men had to go a distance of a mile to obtain water to wash—and consequently didn't wash. The stench in the heads would knock you off your feet. The tents didn't smell much better.

A change in command was made. The weeds were cut. The camp site was cleared up. New heads were built, and the old ones were eliminated. The men were given time and water and told to clean themselves and their clothes. The tin cans behind the galley were cleared away, eliminating a source of flies and mosquitoes. The cooks were told to produce or else. When that same unit was sent back to the States they were given a citation for their outstanding accomplishments.

Of course, in a situation like the one just described, the commanding officer would be held responsible for the conditions as they existed, but, in many cases, attention to details by petty officers can bring about marked improvement in living conditions. After all, the commanding officer has many important things to attend to. He depends on reliable petty officers for attention to details.

One of your primary responsibilities is to check on the living and working conditions of your men. You've got to be on the ball. You should be able to spot defects in living quarters and work areas before the men complain. Think of new improvements before others do. Investigate all complaints by the men under you and get action on valid gripes. During working hours be on the alert to prevent small annoyances that can hamper your men. Make certain that late rations for your working party are served hot. Pick up liberty cards and (if it is station procedure) hand them out well in advance of liberty time.

If you are on the ball, your men will know it. They don't want to be wet-nursed but they expect you to look out for their welfare. When you take care of their interests they will give you their support and cooperation.

GIVING ORDERS

Remember the distinction between an order and a command that you learned during your recruit training days? An order tells a man what to do without requiring him to do it in a certain

way. A command is more exact and usually requires immediate action. Both an order and a command, however, are based on the same principles and that is what you should be interested in.

It is easy to see the need for an order when you are making a decision the men can't possibly anticipate, and when your order is based on information they don't have. Orders are also necessary where the men know pretty well what the work will be. Perhaps the men could make the decision to start putting up the next course of staves where they are erecting a tank, but that's not their responsibility. They expect the order from you. These expected orders put snap into the work and keep the men working as a team. For example, a well-trained section could probably carry out a physical drill under arms without a word from the petty officer in charge; but they go through it with more smartness and energy because of his cadence count.

Use good judgment in deciding when to give an order. Too many orders spoil the result. The better trained your men are, the fewer orders they need. Unnecessary orders will actually slow them down. They will tend to ignore you completely if you keep nagging at them. On the other hand, when you note a slackening in the work or an uneasiness in the men, a simple order may do the trick. It pulls the men back on the job. This is the difference between nagging and giving the needed order.

A good order is clear, simple, and complete. It conveys the necessary information—no more. It gives a man his instructions in a way he can remember. A good order makes clear—

1. WHAT is to be done.
2. WHEN to do it.
3. HOW to accomplish it (if necessary to obtain specific results).
4. WHY it must be done (when practicable to explain).

The WHY gives foundation to the order. It shows the men the importance of the job. When you say, "Splice these wire ropes together; we are out of long lengths of ½-inch rope and need it to reeve a shovel," the man who is to do the splicing knows you aren't just inventing a job to keep him busy. He knows the importance of the job and will do his best to give you a good

strong splice. It is not always possible to give a good reason for the job to be done. Perhaps the officer who assigns you the job doesn't explain the purpose of a particular job and its reason is not immediately apparent. In that case, don't go into elaborate, long-winded, meaningless explanations which will only confuse the man and delay the job. On the other hand, if the instructions are complicated, don't hesitate to give them step by step.

There is a right and a wrong way to give an order. If your bearing is smart, if you look like you mean business, you will get results. But if you slouch and look like you are ready to turn in for the day you might as well tell the men that you don't think the job is worth doing. Stand up like a military man should. LOOK ALIVE! Look straight at the man you're talking to.

The way you speak is also important in giving orders. You can't change your voice or accent, but you can speak clearly and loud enough to be heard. Don't mumble an order, speak distinctly. You can't expect a man to turn to when he has heard only half of the order. You should speak forcefully enough to be heard, and that may have to be pretty loud to be heard over the noise of the work that is going on. However, don't be a "bull of the woods" and continually shout at your men in an effort to scare them into action. It doesn't work and you will lose the respect of your men.

Article 8 of *Navy Regulations* specifically forbids profanity and makes it a court martial offense. Not many of us are "lily pure" when it comes to profanity, but profanity certainly has no place in an order. Profanity adds nothing to the meaning of an order and destroys any emphasis you intended making.

Don't give an order in a low, bored tone, or drawl. If you do, the men will soon feel as tired as you sound. If you coax or wisecrack, you are really not giving orders at all.

The secret of giving a good order is to make it mean business. If everything about your manner and the way you speak your order implies that you expect the job to be well done, it will be.

PRAISE AND REPRIMAND

You won't handle men long before you have to set a man straight. You won't enjoy doing it, no one does except the Petty Officer who is so blown up with his own importance that he likes to throw his weight around. But reprimands are sometimes necessary.

Fix in your mind the purpose of a reprimand. You reprimand a man so he won't make the same mistake twice. The purpose of a reprimand is not to "bawl-out" a man to embarrass him or to let off steam. You reprimand him to point out his mistake and show him the right way, so keep the reprimand impersonal.

Don't "blow your top." Before you give a reprimand count to 10 and make sure of your ground. Investigate the situation thoroughly, checking the facts. Otherwise the man may have a perfectly logical explanation which will make you look foolish.

Once you know the facts, talk to him privately. You are trying to keep him from making the same mistake twice, but you won't, if you humiliate him in front of other men. His emotions will take over instead of his reason and he probably won't even admit the mistake to himself, but rather become resentful and feel that you are picking on him. If you work it right, he won't feel any resentment even though you had to bear down pretty hard on him at first. Wind up by showing him how to improve. After the reprimand, don't hound the man. Treat him as though nothing had happened and watch for results.

It is just as important to give praise as it is to reprimand. Men do better work when they know it is appreciated, and they certainly don't know it is appreciated unless you tell them This doesn't mean that you should pamper your crew with a pat on the head for each right move. Too much of this sort of stuff annoys the men. Give your men broad, general orders when practicable; then let them work out the details for themselves. The job will be done more rapidly, and the men will feel a much greater sense of accomplishment. An occasional tour of inspection and a "Nice going Smith" or "Keep at it Jones" will mean a lot to the crew.

When praise is warranted, it should be given in public. If a man has done an outstanding piece of work, don't wait until later to call him aside to tell him that you think he has done a nice job. Tell him right away in front of the whole crew. If you fall into the habit of taking good work for granted, you may be missing an opportunity to obtain even better work. So be alert to give a word of praise where it is merited.

Make sure that when a man comes up with an idea for improvement, HE gets the credit for it. Imagine you are in charge of an unloading detail and one of your men thinks of a wrinkle that speeds up the operation. The company commander notices the difference and compliments you. Because you are a smart supervisor, tell him in front of the men, who was really responsible for the speed-up of the operations. You will be a straight guy in the minds of both the company and the company commander.

The men don't want phony praise. They recognize soft soap quickly. To mean anything, praise must be based on fact.

LEARN TO LISTEN

The supervisor who fails to listen to the suggestions of his subordinates is missing a good bet. Remember you don't know it all and you are not the only one with ideas. One of your men may have had a lot of experience on pontoon work and his ideas on this particular assembly may be better than yours. Encourage the men under you to express their ideas and make suggestions in line with their work.

When a situation calls for prompt action, you will not have time to wait and get ideas from others. It's your responsibility to make the decision immediately, based upon your knowledge as a first or chief. When time permits it is always a good idea to sound out your men for their ideas. It makes them feel that they are members of the team and their ideas are good.

LEADERSHIP

Good leadership and efficient supervision mean practically the same thing in the Navy. Many men have attempted to

define leadership, or some of the attributes of a leader. In the following list are 49 factors affecting leadership. All leaders do not possess all 49 attributes. Check yourself against the list. Stand up against the yardstick. It will point out your weaknesses, and help you develop the attitudes and ways that characterize the leader.

1. Do I develop zest and enthusiasm in others?
2. Do the men feel that they can confide in me concerning their personal or professional problems and suggestions?
3. Am I entirely fair with the men under me?
4. Do I assign responsibility to my men?
5. Have the men really felt that I am interested in them, their advancement, and their personal problems?
6. Do I set a good example by my own conduct?
7. Do I perform my work thoroughly so that my superiors show that they trust me?
8. Am I constantly trying to increase my professional experience?
9. Do I think well before I make a decision?
10. Do I always praise a good job?
11. Am I a good instructor?
12. Am I a credit and an asset to the Navy in my present job, and a loyal and devoted citizen who not only preaches but practices the basic decencies of life?
13. Do I assume responsibility?
14. Am I a good organizer?
15. Do I understand the significance and fitness of everything I do?
16. Do I believe in what I am doing?
17. Am I tactful, polite, and considerate?
18. Am I military in my conduct?
19. Am I just and impartial in my dealings with those under me?
20. Am I loyal to my superiors and subordinates?
21. Do I understand motivation, and obtain cooperation?
22. Do I select the right men for the right jobs?

23. Do I praise in public and reprimand in private?
24. Do I keep my promises?
25. Do I know all I should know about my men?
26. Am I always available to my men?
27. Do I obey the rules I set for my men?
28. Do I provide for the comfort of my men?
29. Do I instill a fighting spirit in my men?
30. Do I build esprit de corps in my men?
31. Am I self-disciplined?
32. Am I an evaluator of my men and myself?
33. Do I understand my superiors and my subordinates?
34. Do superiors and subordinates understand me?
35. Do I know how to delegate authority?
36. Do I plan ahead?
37. Am I flexible and adaptable to situations?
38. Do I have the quality of patience?
39. Am I a good listener?
40. Am I a good talker?
41. Am I a good disciplinarian?
42. Do I always demand top-notch performances?
43. Am I a good cooperator and team worker?
44. Do I put my every act to this acid test: Does this reflect honor upon my country, upon my uniform, and upon me?
45. Am I proficient in the basic weapons used by all petty officers?
46. Do I make sound decisions?
47. Can I think on my feet?
48. Do I respect my superiors and subordinates?
49. Am I energetic?

QUIZ

1. What is one of the first factors affecting good supervision?
2. Name differences that you will find in the men you are supervising.
3. What problem is created by friendships with the men you are supervising?
4. How should you treat the men under your supervision?
5. Who has the authority to stop liberty?
6. A man under you makes a suggestion for a job you are in charge of. His ideas are followed and as a result the job is ruined. Who is responsible?
7. Which requires immediate action—an order or a command?
8. What does a good order make clear?
9. After reprimanding a man, how should you treat him?

CHAPTER 8

STEELWORKER AS AN INSTRUCTOR

HOW YOU LEARNED

Remember the days when you were learning the different skills of a Steelworker? In looking back over those days, you probably recall that many of the skills seemed quite complex when you first encountered them. But when you had been shown how, they proved relatively easy, didn't they?

The individual jobs were easier because a good instructor showed you how to do them. He possessed all the knowledge, skills, and techniques required to do those seemingly hard-to-understand jobs. But he had something else, too—the art of teaching. Because he was able to explain so clearly what to do and how to do it, he made it seem simple. And because he watched over you while you tried your own hand at doing the job, he was able to point out your mistakes or to help you "remember the next step." By continued practice, under his close supervision, you rapidly mastered the new job.

In your new rate as first or chief, the responsibility of instructing is on YOUR shoulders. You have all the knowledge, skills, and techniques to do the job yourself; but it is up to you to learn "the art of teaching."

YOU AS AN INSTRUCTOR

As a nonrated man you probably had little experience—if any—in teaching. You were too busy learning how to do the job yourself. But that picture changes now that you've learned the job well enough to be given a rating which requires you to pass on your knowledge to others.

Your job as an instructor is to develop in your men the same skills you possess, the skills they will need for satisfactory performance of their job. And it isn't as easy as it sounds. Knowing how to do the job yourself is one thing; but knowing how to teach someone else to do the same job is something altogether different. It is a case where both WHAT YOU SAY and HOW YOU SAY IT are of utmost importance.

Knowing how to instruct is just as important to a Steelworker first or chief as knowing how to do the job himself. Poor instruction will result in sloppy, low-grade work; and you will be censured as the chief of a unit doing bad work. On the other hand, efficient instruction, simply and interestingly presented, brings about an elimination of waste, a high quality and quantity of production, high morale among your men, and recognition of your own abilities.

The art of teaching does not come naturally—it is acquired only through practice and experience. However, if the beginning instructor applies the proper techniques understandingly and conscientiously, good results may be expected from the beginning. Your success as an instructor is partly dependent upon your personality; and you should measure yourself against the yardstick of personality and correct any faults you find in yourself.

The instructor should have five characteristics if he is to succeed in his job—he should be FIRM, FAIR, FRIENDLY, PATIENT, and ENTHUSIASTIC. A trainee who finds out he can "dodge it"

will never learn, and a showing of firmness is the only way to keep many trainees on their toes and making progress. At the same time, a trainee who feels that he is not receiving a fair deal loses all desire to learn. Unless you have the quality of patience, your students will never learn, and unless you are friendly—and you can be friendly without loss of dignity—your trainees will not want to learn.

The instructor must also watch his appearance, his voice, his manner of speaking, and his personal attitudes toward the individual. If he dresses neatly, carries himself well, and moves with snap and precision, the class tends to take on the same characteristics; but, if he is slovenly in his personal appearance, the class will tend in that direction. The speaking manner can also have a definite effect upon the class. Trainees usually judge the instructor by his appearance and his voice. His voice should have expression and strength of tone. He should speak distinctly, and at an understandable speed. He should be able to give proper emphasis at the right time by the pitch or strength of his voice.

The personal attitude of the instructor is infectious. If the instructor is enthusiastic toward his subject, the class will share his enthusiasm. If he shows his sincerity, they will accept it. If he commends the students for their good work, he soon has them working to gain such commendation.

SUBJECT MATTER

No instructor is a good instructor unless he keeps abreast of all the new developments, methods, or materials which help him do his job. Study or review your Navy Training Courses, be familiar with all the textbooks which your men will be using, watch for new developments in your field. The more time you spend in personal study, the less time it will take you to weld your unit into an efficient, well-trained group of Seabees.

TEACHING SITUATIONS

Two types of teaching situations generally used for Navy training purposes are organized classroom instruction and on-the-job instruction. It's hard to say which of the two (if

either) is better. Both have repeatedly proved successful. Most likely, you'll have occasion to use both types of instruction. Therefore, you should understand and know how to conduct either type in the manner that will best bring about the most effective results.

It is possible that you may be assigned as an instructor in a navy training school. When this is the case, much of your teaching will consist of organized classroom instruction. This type of teaching places special emphasis upon the fact that you must be able to put into words the knowledge you have in your head. By careful preparation and planning of your classroom lessons, you will tell, discuss, explain, and demonstrate to your trainees the proper method for performing the various phases of their job. You will teach them all the necessary facts or related information. In Navy training schools space and equipment are normally available, so you will go a step farther and have them perform various jobs on actual pieces of equipment, as well as practice doing many kinds of manipulative operations.

Through on-the-job instruction your men learn by performing actual jobs under actual operating conditions. You will assign a trainee to a certain task, and you'll explain and show him the method and procedure by which it should be done. But instruction does not end there. As the man performs the job, you'll be there, ready to correct him in any errors, and to lend a hand if the situation demands.

On-the-job instruction is frequently supplemented by regular periods of classroom instruction. Quite often a combination of these two teaching situations helps trainees to learn their trade more rapidly than when only one situation is used. Some steelworking jobs require lengthy explanations. That is one reason why it would be impractical to give each man individual instruction on how to do the job. Naturally, the logical way is to teach the necessary facts and theories of the job by the group method of instruction. The commanding officer of your unit may require that you conduct organized classes in steelworking. On the other hand, it may be left

to your discretion to determine whether or not they are necessary.

Maybe you're thinking that on-the-job training is a difficult process by which to learn a job—but it isn't. Usually, it deals with down-to-earth, practical things, such as telling and showing men how to rig a gin pole, how to erect staves for a 10,000-gallon tank, or how to do the thousand-and-one other jobs which contribute to making the Seabees the most outstanding construction unit in the world. The need for doing those jobs exists every day, and every hour of the day. Your unit will be called upon to do many of them, and you will be charged with the responsibility of seeing that they are done. Despite your own admitted skill and knowledge, you can't do all of the jobs yourself. They are unit-assignments, and the entire unit must perform them. Success depends upon how well you have instructed your men in doing their part of the unit-job, and upon how efficient you are as a supervisor.

When you can combine instruction with doing, you speed up the teaching process. Be sure that the trainee does correctly the tasks which you assign him, and be sure that he understands how to do them before he begins. The best instruction is usually individualized, with the instructor first showing the trainee how to do the job, explaining each step as it is performed, then repeating the performance while the trainee tells the instructor what to do at each step. When the instructor is convinced the trainee knows what to do, then the positions should be reversed. Allow the trainee to do the task, telling the instructor what he is doing in each step. The instructor should immediately correct all mistakes which are made. The student should then practice doing the task under the supervision of the instructor until the latter is convinced that the trainee is thoroughly familiar with how to do it and needs only further practice to develop skill.

TECHNIQUES OF INSTRUCTION

In most cases the men you are to train will be eager to learn. It's your job to give them the training they need.

You, as an honest, fair-minded, intelligent instructor—repeat, INSTRUCTOR—should think of your men as trainees who, by

thorough and efficient instruction, can be developed into highly skilled Steelworkers.

Here are the principal techniques which will help you in doing your instruction job. Some of them are more important than others, but all are essential in teaching. Include ALL of them and you will convert those green hands into skilled Steelworkers.

Know Your Subject

You were selected for your job because you know the Steelworker's jobs and techniques. But there will be new things coming up all the time. BE SURE YOU UNDERSTAND HOW TO DO A JOB BEFORE YOU TRY TO TEACH OTHERS TO DO IT. There are books, for example, which will tell you how to do some of the new tasks that come up from day to day. No doubt you already have read some of them, and probably would be able to follow the instructions yourself, but you're training green men. Do you understand it well enough to tell it to others? Be sure. Don't merely repeat the explanation in the book (in parrot-like fashion) or read it aloud to your men. They probably won't understand it unless you EXPLAIN it to them.

Plan Your Instruction

Part of your instruction begins before you actually start talking to your men. This is the PLANNING part. You should not only be familiar with the material you plan to teach, but should have a well-thought-out plan for passing on this information to your men. If you try to teach without a plan, you'll probably muddle through the instruction, and your men will be more confused than helped by your instruction.

Your plan should be simple, inclusive, and conform to need. SIMPLE means that it should be so planned that you do not include at any single instruction session more material than can be readily assimilated by the men. It also means that you should deal with only one subject at a time and that you should present

subject matter in the most understandable form. INCLUSIVE means your instruction should contain ALL the information needed to teach the man to do a particular job. Many instructors know how to do the job so well themselves that they fail to include all the information that some beginner might need to know. To make your instruction CONFORM TO NEED, it should fit into the over-all pattern of your unit. As a petty officer, you need to know what qualifications your men must possess to gain advancement or perform their job efficiently. Your instruction should follow this pattern.

Teach Both Facts and Skills

To do his job well, your trainee will need both SKILL IN THE JOB PERFORMANCE and ABILITY TO DETERMINE WHEN, WHERE, OR HOW TO USE THESE DEVELOPED SKILLS. The skill is learned in the field or shops and comes from practice in doing. Judgment comes from facts learned, usually in classrooms or during discussions.

Break Your Instruction into Logical Steps

Most instructors who fail, do so because they try to teach more at one time than the trainee can absorb. If you break your job into small, simple units and instruct the trainee how to do these units one at a time, allowing him to practice each unit until he becomes proficient in doing it, you find that your pupils learn readily and easily. Part of your planning should be this breaking of a task into smaller units for easier instruction.

Show How Not to Do a Job

Often it is important to show how not to do a job as well as how to do it. Jobs done in a way which the trainee decides is easier might result in loss of life or damage to property. Short cuts observed in the practice of experienced workers might prove dangerous in the hands of novices. Always point out the damages which might result from slipshod, careless, or

inaccurate work, and watch your trainees to see that they do not develop work habits which are incorrect and which would be hard to break, later.

Teach Only the 100 Percent Safe Methods

Often there may be more than one way to do a job, and you as an experienced Steelworker may know all of them. Your trainees need know only one way—they will be able to pick up the others when needed. In your instruction select the one best way to do the job, and teach this to them. Make your selection primarily on the basis of safety, since the trainee will be more awkward or hesitant at first than a skilled worker, and since his awkwardness or hesitancy may cause accidents to himself or others.

Summarize Frequently

From time to time, stop to summarize what you have already told, or shown, your trainees. It helps bring the whole job into the correct perspective, helps to review what has already been said, and makes sure you haven't omitted something important. Don't wait until you have completed your instruction before you summarize what you have already told them. By the end of the instruction period you may have covered so much ground that they will be unable to follow your complete summary. If your instruction extends over more than one period, summarize briefly the material given at previous sessions so the trainee will be able to pick up the new material from a familiar point.

Use Simple Language

Textbooks such as the one you are reading contain a lot of concentrated information, most of which you may want to pass on to your trainees. But if you give it to them as it appears in the texts, they may not find it interesting, helpful, or understandable. To make it interesting to your trainees, you

must first be interested in it yourself. Interest is contagious, and your own enthusiasm will be passed on to your men. But you must still present it in a way which they can understand, will listen to willingly, and be able to use. One way is to "pep up" your talk with anecdotes which illustrate what you are trying to teach. To be sure you are understood, explain all technical words in simple language.

In addition, make your trainees comfortable if you expect them to absorb what you plan to teach. A fidgeting trainee has only half of his attention on your instruction. If he can't see the blackboard which you are using, or the piece of equipment which you are demonstrating, you might as well not be using it. Remember that no speaker can hold the attention of his audience for long periods, so keep your instruction brief and pointed. Remember that something new perks up lagging interest—so do something to create a change whenever interest seems to be lagging.

Make Them Want to Learn

No matter how well you present your subject, the trainee will not learn unless HE WANTS TO LEARN. Part of your job is to create this desire to learn. You can do it by showing him the benefits to be gained from this instruction. If he sees it as a step toward promotion, for example, he is more anxious to understand your instruction. Pride of craftsmanship, competitive spirit, or cooperation are all excellent ways to create a desire to learn.

Remember that Your Men Are Individuals

No two men are exactly alike. A good instructor takes advantage of this fact by planning his instruction to take advantage of the differences between individuals. Some persons learn more quickly when spurred on by competition, others need some personal reward. One person may be able to learn best by doing, another needs to see the explanation in print to understand it.

Some learn quickly, others must pore over a subject for long hours. The instructor who is able to size up the men under him and train them in a manner which takes complete advantage of their individual differences always does the best job of training.

Teach It Right the First Time

Incorrect habits are difficult to break, and a trainee learns more the first time he does a task than at any other time. As an instructor you should see that he follows the correct method the first time he does a job. Stop him if he makes a mistake—at the time he makes the mistake, not after the task is completed—and point out the error. Have him practice doing correctly the step in which he made the mistake until he has the correct technique down perfectly.

Have the Trainee Do the Job

In your instruction, it isn't enough to show or tell a trainee how to do the job. He learns by doing. And he learns best if he does the task as soon as he has learned how to do it. If you provide instruction at one session and he does not have an opportunity to practice what he has learned right away, he may have forgotten much of it by the time he is called upon to do it. Or, he may do it incorrectly, and need to "relearn" his lesson.

Don't Permit Safety Violations

Don't permit your trainees to learn bad habits. Even though they may succeed in doing something without harm to themselves or others on the first occasion, they may not be as lucky the next time. They will probably continue to do the job just as you have let them do it the first time. If they do violate a safety measure, stop them and carefully explain what might have happened by doing it that way. Then show them how to do it safely and have them practice doing it by this correct method.

Use Training Aids

A trainee learns best when he is TOLD and SHOWN, and allowed to DO. To do this three-part job, make use of any training aids

which are available. Films, models, blow-ups, diagrams, charts, trainers, and recordings are all useful, and should be used whenever they can help you do a better job. Usually these are available from the training officer, and should be requisitioned from him when needed. Often, however, you can improvise your own. Part of your job is done if you have assembled IN ADVANCE the training aids you will need and made sure you know how to use them. The actual material or equipment used in the field is the best training aid you can use.

Ask Questions

By asking questions you are better able to determine whether your trainees have understood your instruction and are able to use it intelligently. Plan your questions in advance, and determine the best time to ask them. Avoid questions which will be answered by a simple "yes'" or "no". By forcing him to explain his answer, you are making him think about the subject of your question, and thus he will clarify his own thinking. If the answers are incorrect, stop immediately while you make sure this trainee and any others in the group clearly understand the correct answer. An incorrect answer may indicate faulty instruction on your part and may even require you to go back and repeat some of the instruction.

PUBLICATIONS FOR NAVY INSTRUCTOR

To help you to become a better instructor, the Navy has several publications. The *U. S. Naval Training Bulletin* is published monthly by the Bureau of Naval Personnel. It contains articles on training that you will find both interesting and helpful to you as an instructor.

The *Manual for Navy Instructors* (NavPers 16103B) is another publication you should read and study. This manual sets forth the essential areas of knowledge and procedure necessary for a good background as an instructor. In this book you will find many ways to increase your efficiency.

PRACTICE

As an instructor, your principal job is to train men in your unit so that they may become an efficient, well-trained, cooperative group in the shortest possible time. While your actual training task never ends, since there are always new men coming into the unit or new tasks to be worked out, your job of instruction becomes easier as you become more familiar with the use of the various training techniques. And you will become familiar with these through practice and use, just as the men you are training will become proficient in their tasks as you train them and they use their newly-won skills.

But remember—IF THE TRAINEES HAVE NOT LEARNED, THE INSTRUCTOR HAS NOT TAUGHT. You are measured as an instructor by the success of the men you train, not by your own abilities.

QUIZ

1. What five characteristics should an instructor have to succeed in his job?
2. What two types of teaching situations are generally used for Navy training purposes?
3. Before you begin your instruction, what should you do?
4. Cite the most frequent cause of instructor failure.
5. When there is more than one way to do a job in what way(s) should you teach?
6. What should you do to bring the whole job into correct perspective, help review, and make sure you have omitted nothing?
7. If you are teaching a man to splice, when will he learn most?
8. What will be your best training aids?

APPENDIX I
WIRE ROPE SPECIFICATIONS

Equipment	Line	Wire rope diameter	Wire rope lengths					
		In.	Ft. In.					
MODEL 25 NORTHWEST SHOVEL:								
18-foot boom	Hoist	3/4	94 0					
15-foot 3½-inch stick	Back haul	5/8	27 7					
	Crowd	5/8	50 0					
	Dipper-latch	9/16	43 0					
	Boom hoist	9/16	115 0					
			Boom length					
			30 feet	35 feet				
			Ft. In.	Ft. In.	Ft. In.			
CLAMSHELL	Closing	5/8	105 0	114 0				
	Hold	5/8	75. 4	84 0				
	Tagline	5/16	65 0	70 0				
HOIST-FOR-HOOK BLOCK	2 partline	5/8	104 0	117 0				
DRAGLINE	Drag	3/4	45 0	50 0				
	Hoist	5/8	72 0	81 0				
TOPPING LIFT	Boom hoist	9/16	158 0	178 0				
PULL SHOVEL	Boom hoist	5/8	105 0					
	Shear leg	2/16	50 0					
	Drag	3/4						

Equipment	Line	Wire rope diameter	Wire rope lengths					
		In.	Ft. In.					
			Boom length					
			30 feet	35 feet				
MODEL 6 NORTHWEST PULL SHOVEL	Boom hoist	¾	155 0	...	...	...	...	...
	Shear leg	¾	90 0	...	...	...	...	...
	Drag	⅞	87 0	...	...	...	...	...
SHOVEL: 25-foot boom 18-foot stick	Hoist	1	114 0	...	...	...	...	...
	Back haul	1	60 0	...	...	...	...	...
	Crowd	1	56 0	...	...	...	...	...
	Dipper-latch	⅜	40 0	...	...	...	...	...
	Boom hoist	⅞	145 0	...	...	...	...	...
			Boom length					
			45 feet	50 feet	55 feet	60 feet		
		In.	Ft. In.	Ft. In.	Ft. In.			
CLAMSHELL	Closing	¾	134 0	143 0	152 0	161 0	...	...
	Hold	¾	98 0	107 0	116 0	125 0	...	...
	Tagline	⅜	62 6	65 6	69 6	73 0	...	...
HOIST-FOR-HOOK BLOCK	Two-fold purchase	¾	265 0	290 0	315 0	340 0	...	...
DRAGLINE	Drag	⅞	74 0	74 0	74 0	74 0	...	...
	Hoist	¾	127 0	133 0	140 0	147 0	...	...
TOPPING LIFT	Boom hoist	¾	237 0	256 0	275 0	294 0	...	...

Equipment	Line	Wire rope diameter	Wire rope lengths					
		In.	Ft. In.					
			Boom length					
			50 feet	60 feet		70 feet	75 feet	80 feet
MODEL 80D NORTHWEST SHOVEL:								
27-foot 6-inch boom	Hoist	1⅛	119 0	...	...	...	...	...
18-foot 4-inch stick	Back haul	1	63 0	...	...	...	...	...
	Crowd	1	56 0	...	...	...	...	...
	Dipper-latch	⅜	43 0	...	...	...	...	...
	Boom hoist	¾	185 0	...	...	...	...	...
			Boom length					
			50 feet	60 feet		70 feet	75 feet	80 feet
			Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
CLAMSHELL	Closing	⅞	165 0	185 0	194 0	203 0	213 0	222 0
	Hold	⅞	125 0	145 0	154 0	163 0	173 0	182 0
	Tagline	⅜	85 0	85 0	85 0	85 0	85 0	85 0
HOIST-FOR-HOOK BLOCK	Two-fold purchase	¾	290 0	340 0	365 0	390 0	415 0	440 0
DRAGLINE	Drag	1	69 0	76 0	79 0	79 0	79 0	79 0
	Hoist	⅞	123 0	138 0	149 0	155 0	164 0	172 0
TOPPING LIFT	Boom hoist	¾	317 0	317 0	317 0	317 0	317 0	317 0

Equipment	Line	Wire rope diameter	Wire rope lengths					
			Boom length					
		In.	50 feet	60 feet		70 feet	75 feet	80 feet
MODEL 82 LORAIN SHOVEL:								
23-foot boom	Hoist	⅞	85 0					
18-foot stick	Boom hoist	¾	200 0					
	Dipper trip on turntable	⅜	19 0					
	Dipper trip (on stick)	⅜	30 0					
			Boom length					
			50 feet	70 feet				
			Ft. In.	*Ft. In.*				
CLAMSHELL	Closing	¾	175 0	210 0				
	Hold	¾	115 0	150 0				
	Tagline	⅜	70 0	80 0				
HOIST-FOR-HOOK BLOCK	Two-fold purchase	¾	295 0	395 0				
DRAGLINE	Drag	⅞	70 0					
	Hoist	¾	120 0					
TOPPING LIFT	Boom hoist	¾	205 0	205 0				
MODEL LP CARRY-ALL	Hoist	½	105 0					
WIRE ROPE	Dump	½	126 0					
SPECIFICATION:								
12-cubic yard Le Tourneau	Apron to sliding sheave	⅝	14 6					

Equipment	Line	Wire rope diameter	Wire rope lengths					
	Tailgate to spiral sheave	⅝	13 6					
	Tailgate to sliding sheave	⅞	51 0					
	Spring pipe cable	⅝	17 0					
			Rope lengths					
MODEL M SCRAPER	Hoist	½	65 0					
WIRE ROPE	Dump	½	106 0					
SPECIFICATION: 6-cubic yard Le Tourneau	Spring pipe							
	Spiral sheave	½	15 0					
	To tailgate	½	10 6					

APPENDIX II

ANSWERS TO QUIZZES

CHAPTER 1

ON THE WAY UP

1. The *Welding Encyclopedia.*
2. *Pontoon Gear Handbook* (NavDocks TP-PL-7).
3. Those qualifications that apply to 3, 2, and 1.
4. The staff of the area commander.
5. Surveyors.

CHAPTER 2

RIGGING HEAVY EQUIPMENT

1. The wire rope specifications for that particular piece of equipment.
2. In the manufacturer's manual and in the appendix of this book.
3. The reeving diagram and the reeving instructions. This information is contained in the manufacturer's manual.
4. Draw your own reeving diagram.
5. Reeving a twofold purchase.
6. The crowd line, the backhaul line, and the hoist line.
7. It raises and lowers the dipper stick.
8. Horizontal position.
9. When you are sure there are no twists in the lines.
10. Class 22.
11. To support and protect material stored.
12. To run a safe job.

CHAPTER 3

BUILDING WITH WOOD

1. The sill.
2. Joists support floors and the ceiling.
3. Studs.
4. Rafters.
5. Balloon framing and platform framing.
6. Platform framing.
7. Laminated, solid, lapped, and box.
8. A carrying joist.
9. A T-post.
10. To tie the studding together and form a finish for the walls, to act as a support for the lower ends of the rafters, and to support the ceiling joists.
11. The span.
12. The seat cut.

CHAPTER 4

STEEL

1. Iron ore, coke, and limestone.
2. Carbon.
3. It increases the tensile strength.
4. It has no effect.
5. Open-hearth, Bessemer, and electric furnace.
6. The basic open-hearth method.
7. In the Bessemer process, air is blown through molten pig iron in a Bessemer converter.
8. To improve the quality of the steel and to form it into shapes more suitable for use.
9. Rolling.
10. By drawing steel rod through successively smaller dies.

11. 0.30 to 0.60 percent.
12. Toughness.
13. Stress is the amount of internal force which resists a change in the form of a body or mass.
14. Slip the pipe on the bar and then proceed to make the bends needed, employing the use of either steel plugs or angles bolted to the table.
15. The lever is moved to the right for a right-hand bend and to the left for a left-hand bend.
16. Efficiency in handling work and safety of personnel and equipment.
17. Designate and label each rack according to the size of rod to be stored in it.
18. As a safety precaution, men handling reinforcing steel should always wear leather gloves.

CHAPTER 5

STEEL FABRICATION

1. A scriber.
2. 45° and 90°.
3. Trammel points.
4. $\frac{1}{16}$ inch.
5. Draw a full-sized plan and elevation of the desired shape.
6. Controlled expansion and normal contraction.
7. They are fused to the base metal by welding.
8. Iron-base alloys, tungsten and cobalt alloys, and tungsten carbide.
9. Reversed polarity.
10. The surface between two riveted parts.

CHAPTER 6

TECHNIQUES AND TROUBLE SHOOTING IN WELDING

1. Shrinkage of deposited metal, nonuniform heating of parts, and improper welding sequence.
2. By eliminating rigid joints, increasing size of weld, welding in full-sized short sections, making sure welds are sound and fusion is good, and preparing joints with uniform and proper free space.
3. Improper preparation of the joint, use of too large welding rod or too small torch tip, insufficient heat input, and too fast a welding speed.
4. Use electrodes for welding in the position for which they were designed, use moderate current at proper welding speed, and use proper electrode for weld to be made.
5. In welding joints between pipes, and between pipes and welding-type fittings, butt welding of flanges, and welding stubs.
6. To secure tightness.
7. By machining, grinding, or oxyacetylene cutting torch.
8. Spacers provide a means for maintaining the specified root opening. They also provide a convenient location for tack welds.
9. Scaling or flaking of weld metal.
10. When the wall thickness is ¾ inch and over and the service temperature is in excess of 250° F.
11. When flammable or explosive materials will be exposed to welding or cutting operations.
12. The horizontal rolled position, the horizontal fixed position, or the vertical fixed position.
13. The weld is started at the bottom and progresses upward to the top of the pipe—first on one side, then on the other.

CHAPTER 7

SUPERVISION

1. The job plan.
2. Differences in home background, education, mentality, and skill.
3. The problem of favoritism.
4. As individuals.
5. The commanding officer.
6. You are.
7. A command.
8. What, when, how, and why.
9. As though nothing had happened.

CHAPTER 8

STEELWORKER AS AN INSTRUCTOR

1. Firmness, fairness, friendliness, patience, and enthusiasm.
2. Organized classroom instruction and on-the-job instruction.
3. Plan your instruction.
4. Failure to divide the instruction into small simple units.
5. The safe way(s).
6. Summarize frequently.
7. On the first splice he makes.
8. The actual material and equipment used in the field.

APPENDIX III

QUALIFICATIONS FOR ADVANCEMENT IN RATING

STEELWORKERS (SW)

RATING CODE NO. 5700

General Service Rating

Scope

Steelworkers rig and erect A frames, gin poles, derricks, booms, and blocks and tackle; operate winches and hoists in moving and hoisting operations; erect and dismantle the following steel structures—bridges, buildings, storage tanks, towers, and pontoons; place, fit, weld, cut, and bolt steel shapes, pipes, plates, and built-up sections; splice fiber and wire rope; fabricate nets and slings and rig cable assemblies used in heavy construction.

Emergency Service Ratings

STEELWORKERS S (Structural Steelworkers), Rating Code No. 5701 .... **SWS**

Erect and dismantle steel structures; place, fit, weld, cut, and bolt steel shapes, pipes, plates, and built-up sections.

STEELWORKERS R (Construction Riggers), Rating Code No. 5702 .... **SWR**

Rig and erect A frames, gin poles, derricks, booms, and blocks and tackle; operate winches and hoists in moving and hoisting operations; splice fiber and wire rope; fabricate nets and slings and rig cable assemblies used in heavy construction.

Navy Job Classifications and Codes

For specific Navy job classifications included within this rating and the applicable job codes, see Manual of Enlisted Navy Job Classifications, NavPers 15105 (Revised), codes SW–6000 to SW–6099.

Qualifications for Advancement in Rating	*Applicable rates*		
	SW	SWS	SWR
100 PRACTICAL FACTORS			
101 OPERATIONAL			
1. Select and use hand tools commonly employed in:			
a. Rigging of heavy construction equipment assemblies	3	3	3
b. Erection and dismantling of steel structures	3	3	3
2. Read simple working drawings and sketches	3	3	3
3. Cut wire rope and steel plates and bars with oxyacetylene torch	3	3	3
4. Reeve common blocks and tackle and act as hook-on man and guide for moving loads	3	3	3
5. Set up and adjust oxyacetylene equipment to produce carburizing, neutral, and oxidizing flames	3	3	3
6. Serve as helper in:			
a. Assembling pontoon structures	3	3	3
b. Erecting or dismantling steel structures	3	3	3
c. Bending reinforcing bars; raising, placing, and tying reinforcing steel	3	3	---
7. Set up, adjust, and connect d. c. arc welders for straight polarity and reverse polarity work	3	3	---
8. Perform electric arc welding on mild steel plate in a flat position	3	3	---
9. Splice fiber rope and make cargo nets	3	---	3
10. Work from working drawings, specifications, and sketches	2	2	2
11. Erect or dismantle steel towers, tanks, buildings, and bridges. Climb and work in raising gang as a connector or tag man	2	2	2
12. Assemble a pontoon	2	2	---
13. Assemble pontoon structures	2	2	---
14. Perform electric arc welding on mild steel in vertical and overhead positions	2	2	---
15. Perform oxyacetylene welding on mild steel plate in a flat position	2	2	---
16. Cut structural steel shapes with oxyacetylene torch	2	2	---
17. Splice wire rope and make slings	2	---	2

	Qualifications for Advancement in Rating	SW	SWS	SWR
101	OPERATIONAL—Continued			
	18. Use blocks and tacke, winches, hoists, jacks, rollers, cables, and slings to move heavy objects; erect scaffolding; erect and use A frames, gin poles, and derricks	2	2	2
	19. Bend, place, and tie reinforcing steel in accordance with plans and specifications	2	2	---
	20. Rig cable assemblies used on heavy construction equipment	1	---	2
	21. Set up and operate a reinforcing-steel bending shop	1	1	---
	22. Make electric arc welded joints on steel pipe in place	1	1	---
	23. Perform all position oxyacetylene welding on mild steel plate	1	1	---
102	MAINTENANCE AND/OR REPAIR			
	(No minimum qualifications.)			
103	ADMINISTRATIVE AND/OR CLERICAL			
	1. Prepare progress reports, job orders, and work requisitions	1	1	1
	2. Make sketches for rigging and steelworking	1	1	1
	3. Make material estimates from working drawings, sketches, and specifications	1	1	---
	4. Supervise and train personnel engaged in:			
	a. Assembly of a pontoon and pontoon structures	1	1	---
	b. Bending and placing reinforcing steel	1	1	---
	c. Rigging	1	---	1
	d. Erecting and dismantling steel towers, tanks, buildings, and bridges	C	C	---
	5. Lay out and direct cutting and welding of structural steel shapes and built-up members	C	C	---
200	EXAMINATION SUBJECTS			
201	OPERATIONAL			
	1. Selection and use of tools, materials, methods, and equipment common to rigging and steelwork	3	3	3
	2. Standard hand signals for directing equipment operators	3	3	3
	3. Basic types and shapes of structural and reinforcing steel	3	3	3

Qualifications for Advancement in Rating		SW	SWS	SWR
201	OPERATIONAL—Continued			
	4. Construction and uses of the common types of hoisting rigs; mechanical advantages of the common block and tackle arrangements	3	3	3
	5. Construction and erection of gin poles, A frames, stiff-leg derricks, and dead men	3	3	3
	6. Methods and procedures for assembling and launching pontoon structures	3	3	3
	7. Types and uses of wire rope. Uses of the various wire and manila rope splices	3	3	3
	8. Safety precautions to be observed in rigging, welding and steelwork	3	3	3
	9. Sizes, care, stowage, and uses of manila and wire rope. Lubrication of wire rope	3	3	3
	10. Types of various welds and their strengths	3	3	---
	11. Types and uses of electrodes, filler rods, and fluxes for welding ferrous metals	2	2	---
	12. Types and application of welded joints	2	2	---
	13. Methods of controlling expansion during welding. Preheating, skip welding, spacing, and transfer of heat	2	2	---
	14. Methods and procedures for fabrication of steel structures and shaping of various steel plates in shop or field	1	1	---
	15. Methods of construction and erection of simple wooden framing including rafters, subfloors, partitions, and heavy timber members, including stringers, braces, fenders, beams, and floors	C	C	C
	16. Methods of visual inspection of welds	C	C	---
202	MAINTENANCE AND/OR REPAIR (No minimum qualifications.)			
203	ADMINISTRATIVE AND/OR CLERICAL			
	1. Functions of operational companies of a Construction Battalion	3	3	3

INDEX

U. S. GOVERNMENT PRINTING OFFICE: 1954